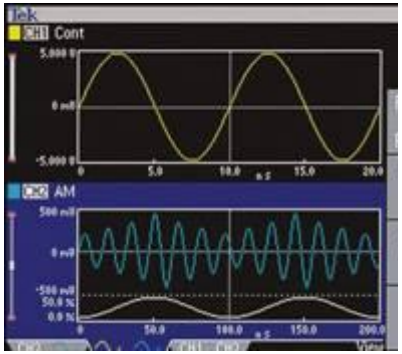
高速光通讯测试



泰克科技（中国）有限公司

Tektronix

主题

- 采样示波器基础及应用
- 光信号测试的项目以及要点
- 如何改善光信号测试的精度，一致性以及重复性
- 泰克10G/25G/40G/100G的测试方案
- 高速信号源和误码仪在光通信中的应用

采样示波器基础：采样示波器的特点

- 高带宽

  目前，泰克DSA8300示波器的带宽高达80G+

- 高等效采样率

  泰克DSA8300示波器等效采样率高达1000T以上

- 高垂直电压分辨率

  泰克DSA8300示波器的ADC分辨率为16bit

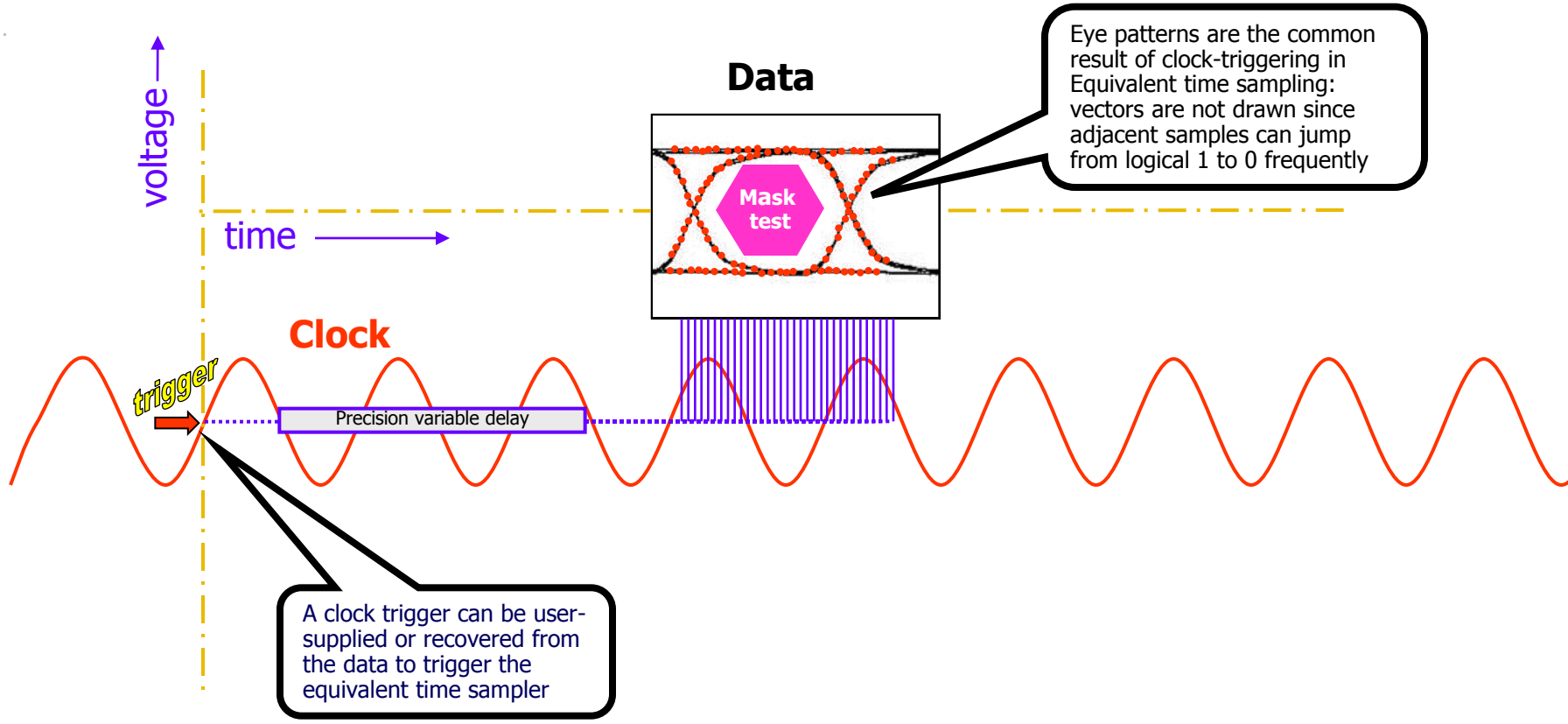
- 低触发抖动

  泰克DSA8300触发抖动低至100fs以下

- 低本底噪声

  泰克80Exx噪声低至300uV（RMS）

采样示波器采样原理：
需要同步触发信号，多次触发完成捕获



- *When a clock signal is used to trigger the equivalent-time 8300 scope the sampled DATA signals generally create EYE PATTERNS (between clock triggers the sampled DATA could be either a logical 1 or 0)*

采样示波器的优势及应用

- 带宽高达80GHz以上

  进行高速的周期脉冲测试

  进行高速的串行数据分析

- 噪声低、高垂直分辨率(16bit)

  进行高速的眼图测试以及噪声分析。

- 超低的触发抖动(使用82A04B的模块使触发抖动减少至100fs)

  进行高速的串行数据抖动分析

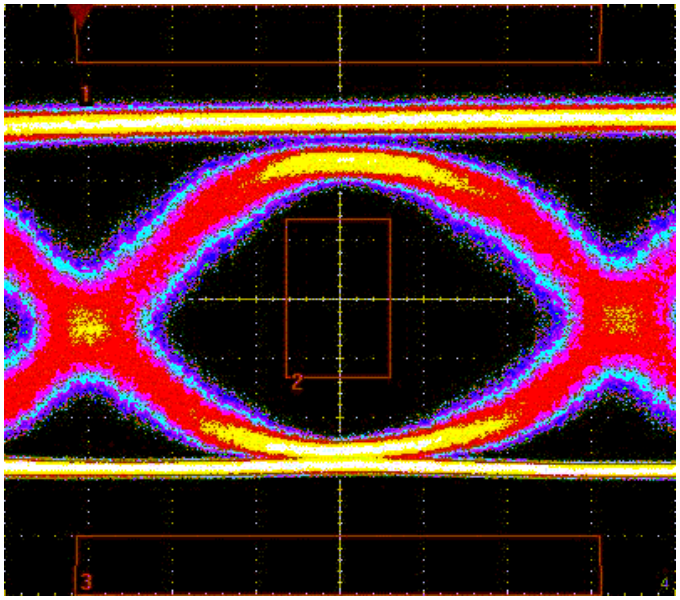
光通信基础知识介绍-常用光波长

- 目前，按照光信号在光纤中的传播方式有单模与多模之分；其波长也不一样。主流的波长有780、850、1310、1550nm
- 单模：9um光纤直径，波长多为1310、1550nm
- 多模：62.5um光纤直径，波长多为780、850nm

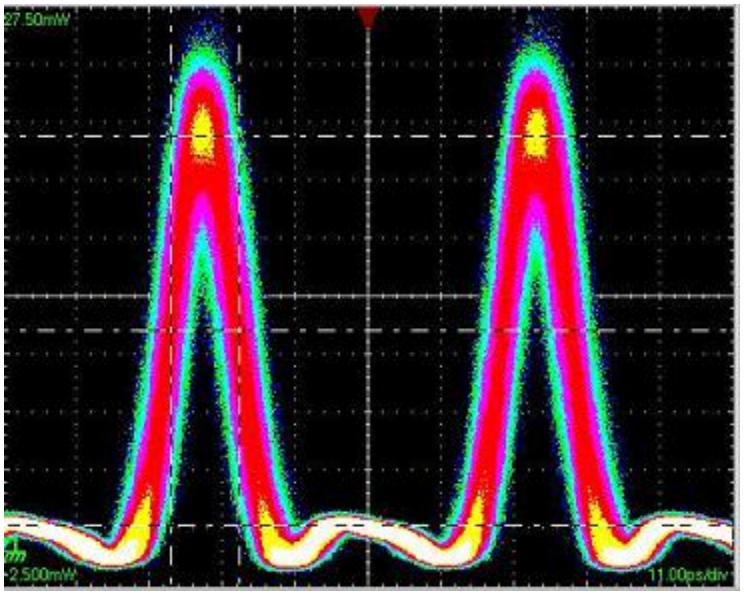
Optical standard

Standard	Line Rate
OC-3/STM-1	155 Mb/s
OC-12/STM-4	622 Mb/s
FC1063	1.0625 Gb/s
ENET1250	1.250 Gb/s
FC2125	2.125 Gb/s
OC48//STM48, GBE, INF2500	2.488 Gb/s 2.500 Gb/s
FEC2.666	2.666 Gb/s
!0GBASE-X4, FC3188	3.125 Gb/s 3.188 Gb/s
FC4250	4.250 Gb/s
INF5000	5.000 Gb/s
OBSAI6144	6.144 Gb/s
CPRI7373	7.373 Gb/s
FC8500*8, OC-192/STM-64, 8GFC, 10GBASE-W, 10GBASE-R, 40GBASE-R4, 100GBASE-R10, 10GFC, FEC10.66, FEC10.71, FEC11.10, FC11317	8.500, 9.95,10.31, 10.51,10.66,10.71,11.1, 11.3 Gb/s ORR Filters plus Unfiltered bandwidth path (typically 12 GHz)
100GBase-LR4, 100GBase-ER4 Infiniband EDR (LW)	4 x 25.781 Gb/s
100GBase-LR4 + FEC, 100GBase-ER4 + FEC	4 x 27.739 Gb/s
40GBase-FR	41.25 Gb/s
OC-768 / STM-256, VSR-2000	39.813 Gb/s
OTU3 (OC-768 + G.709 FEC), VSR-2000 , 4x10G LAN-PHY (OTU3)	43.018 Gb/s 44.50 Gb/s

NRZ和RZ两种编码的眼图比较



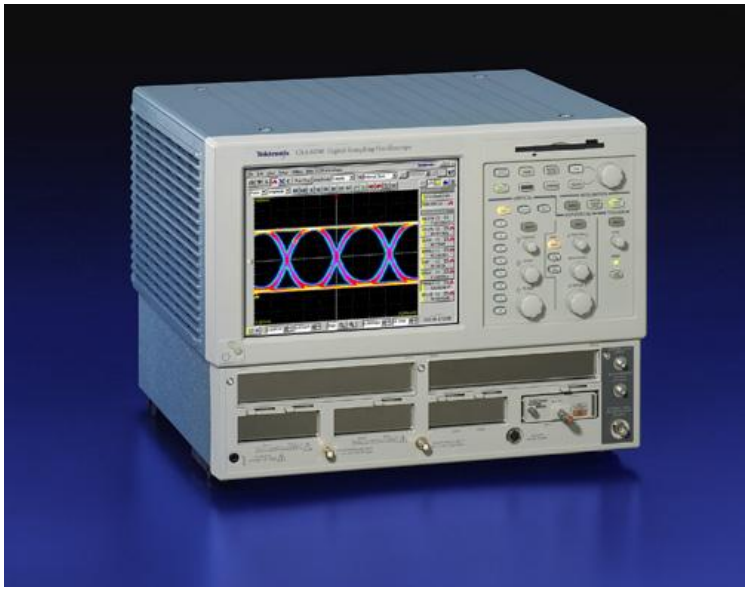
NRZ编码眼图，高功率电平为逻辑1，低功率电平为逻辑0，在两高低两阶跳变。



RZ编码眼图，底部有一根线为逻辑0，逻辑1显示为脉冲。

使用Tektronix DSA8300能完成什么测试？

- **核心测试**
  - 眼图测试
  - 抖动测试
  - 幅度域
    - 平均光功率(AOP)
    - 消光比(ER)
    - 光调制幅度(OMA)



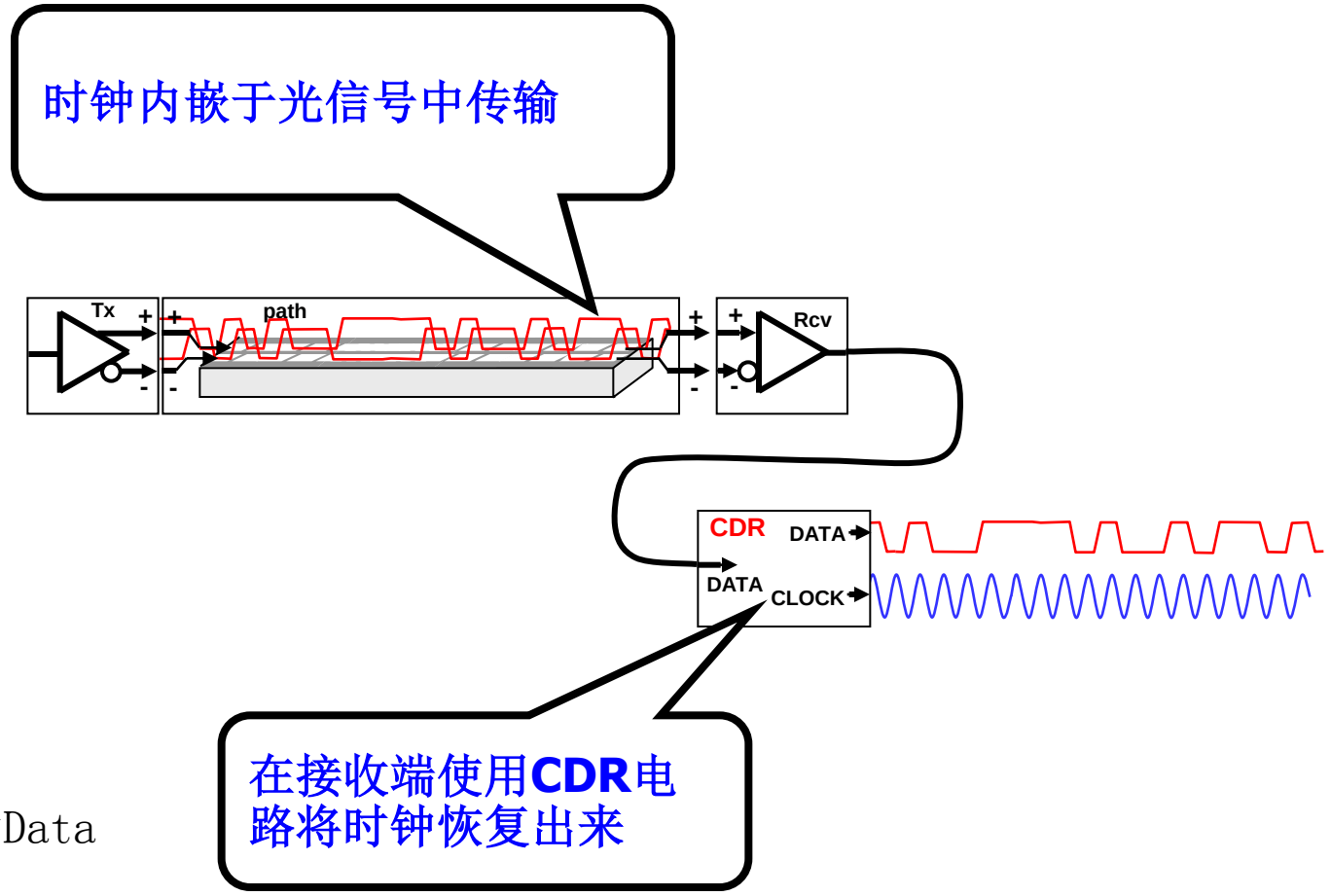
使用Tektronix DSA8300需要那些配置？

- **核心测试**
  - 光采样模块（滤波器）
    - 带有4阶Besel-Thomson低通滤波器，且滤波器的带宽为DUT数据率的0.75倍
  - 时钟恢复单元/模块(CRU)
    - 可以恢复DUT数据率相对应的时钟，且该CRU具有带宽为DUT数据率1/1667的低通滤波器

光接口物理层测试的几项要求

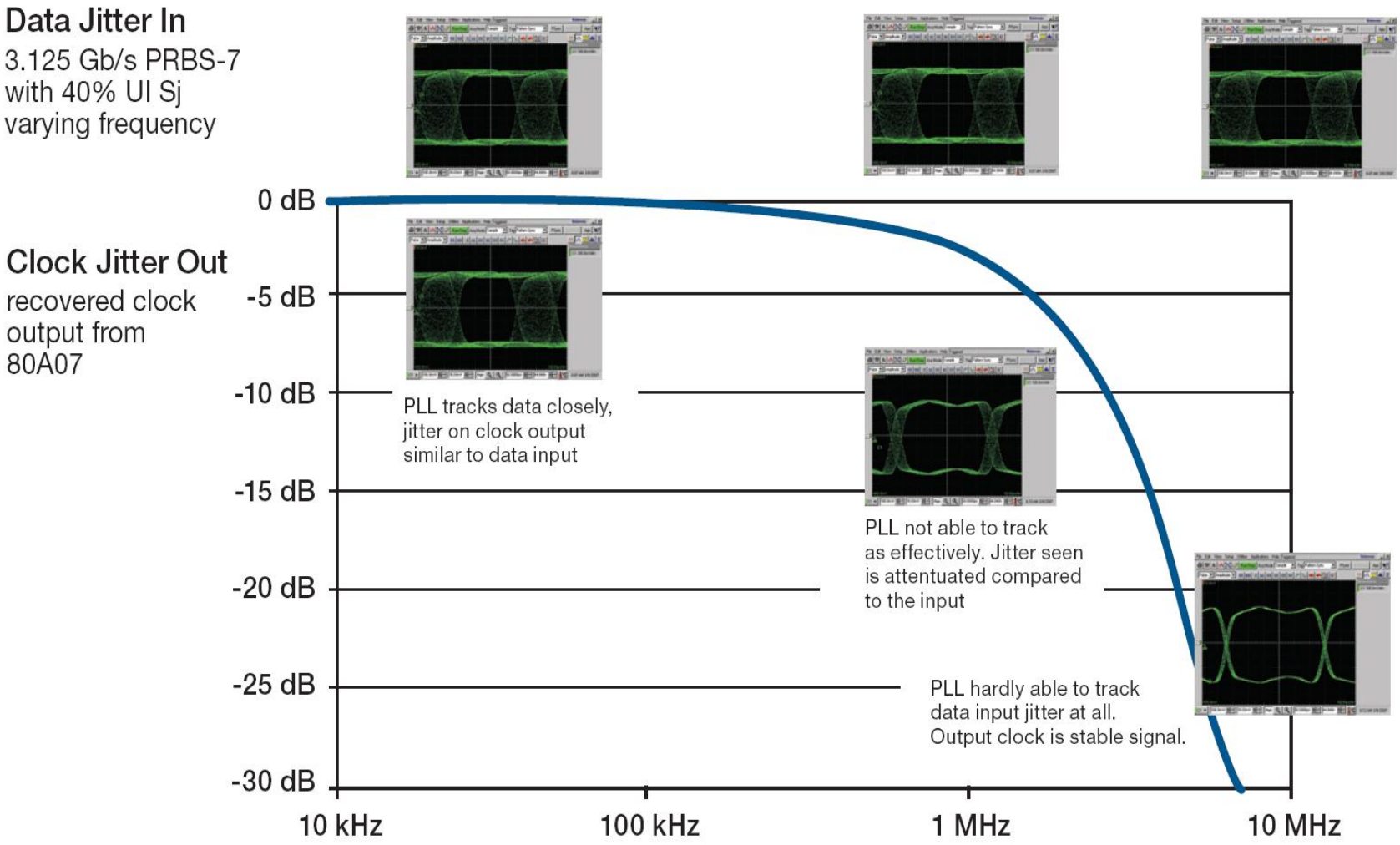
- 对时钟恢复CDR的要求
- 对噪声，灵敏度的要求
- 对滤波器的要求
- 对波长的要求
- 对抖动的要求（最新的40G/100Gbps的标准）

光接口物理层测试：对CRU的要求



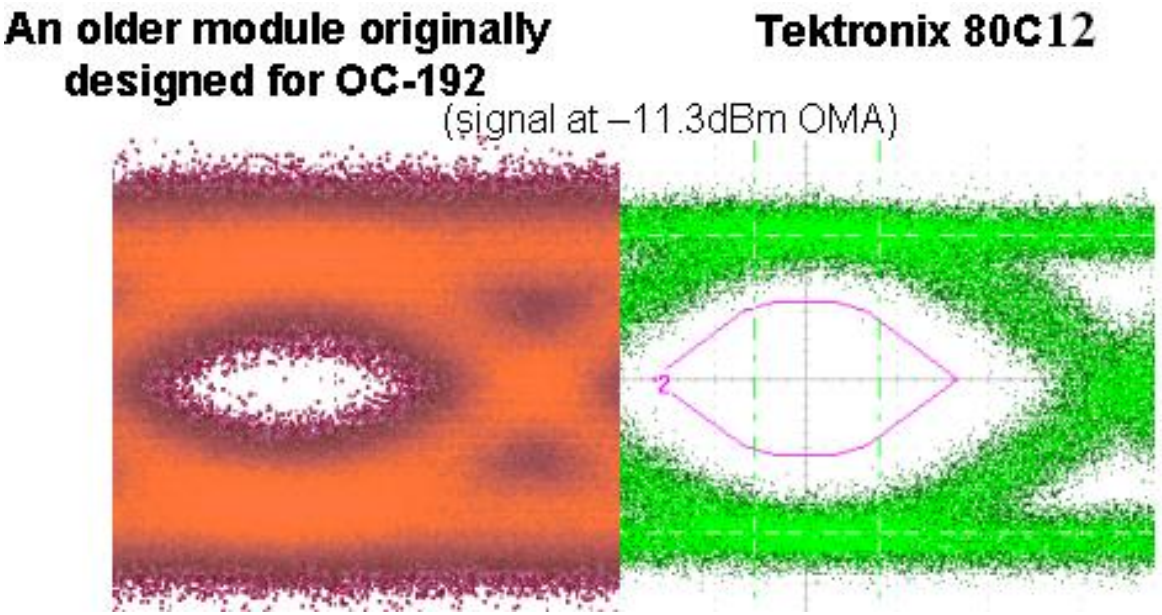
要求CDR的环路带宽为Data rate/1667

光接口物理层测试：对CRU的要求



光接口物理层测试：噪声/灵敏度要求

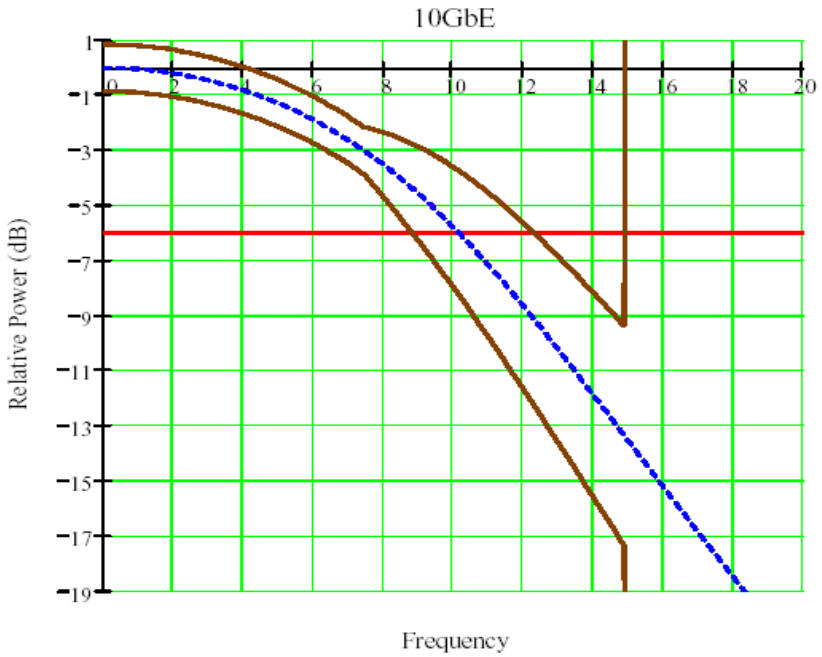
在测试小功率光模块或者超长波长光模块时，DUT的光功率会很小。所以模块的噪声必须很低，灵敏度很高，达到一定的信噪比，测试的结果才能准确，而显示出来的信号噪声是真正属于信号的，而不是模块自身的噪声。



光接口物理层测试：对滤波器的要求

测试眼图模板时，需要使用Optical Reference Receiver 光参考接收器(O/E + Filter), 信号首先经光电转换, 然后经4th Order Bessel-Thomson 滤波器过滤，按业界规范要求，此滤波器的带宽要是被测信号速率的0.75倍

业界测试光接口 所使用的4th Order Bessel-Thosom 滤波器的频响如下:



不一样的速率，有不一样的滤波器要求

光接口物理层测试：对波长的要求

- 目前，按照光信号在光纤中的传播方式有单模与多模之分；其波长也不一样。主流的波长有780、850、1310、1550nm
- 单模：9um光纤直径，波长多为1310、1550nm
- 多模：62.5um光纤直径，波长多为780、850nm

光通信中的性能参数：OMA与ER

- 逻辑1和逻辑0:

  光功率高的状态是逻辑1，反之则为逻辑0.

  光功率常用:dBm = 10log(Power(mW)/1(mW))

- OMA:Optical Modulation Amplitude

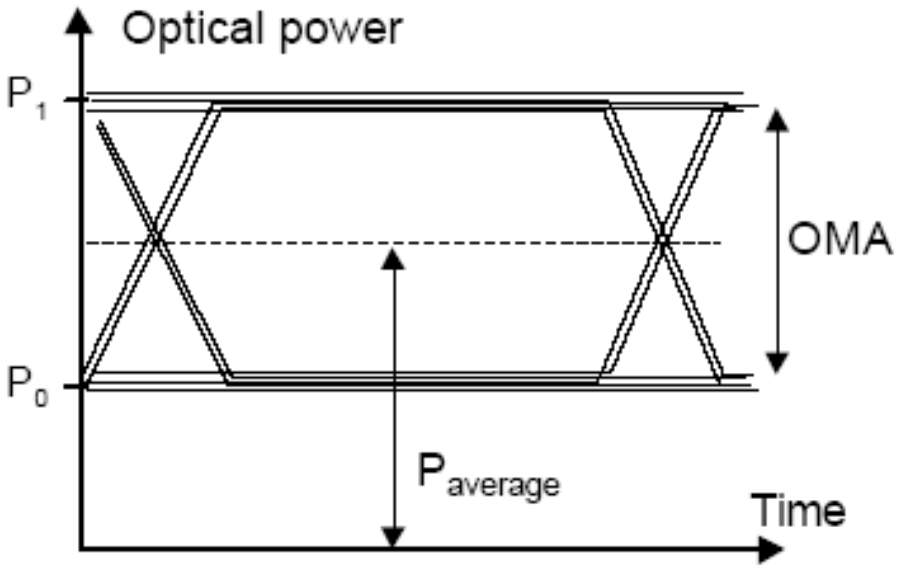
  逻辑1和逻辑0光功率差:

  OMA=P1-P0

  有时也定义成:

$$OMA = 2P_{average} * \frac{\frac{P1}{P0} - 1}{\frac{P1}{P0} + 1}$$

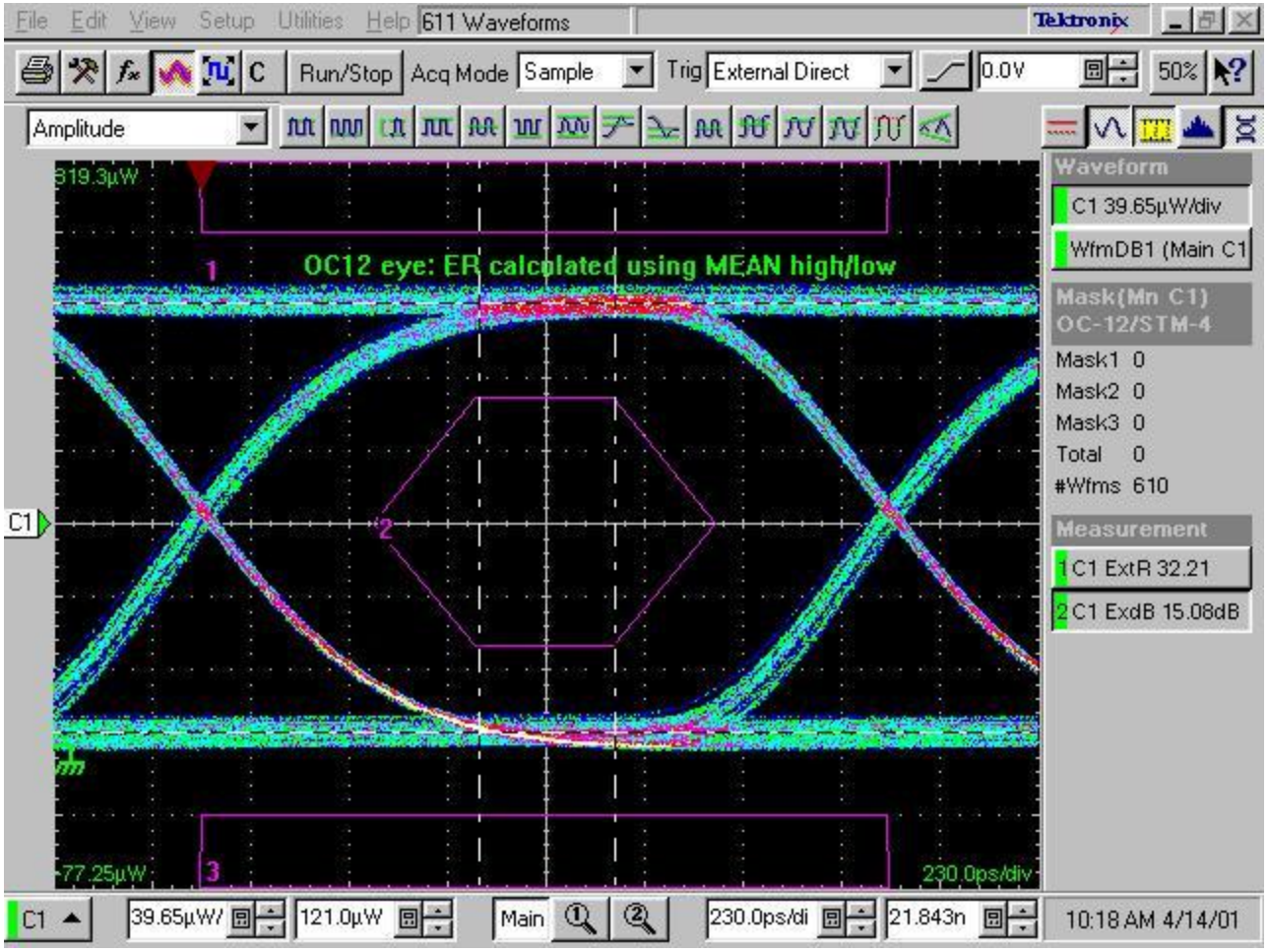
$$P_{average} = \frac{P1 + P0}{2}$$



ER:Extinction Ratio,消光比

$$ER = \frac{P1}{P0}, dB = 10\log_{10}\frac{P1}{P0}$$

光通信中的性能参数：OMA与ER

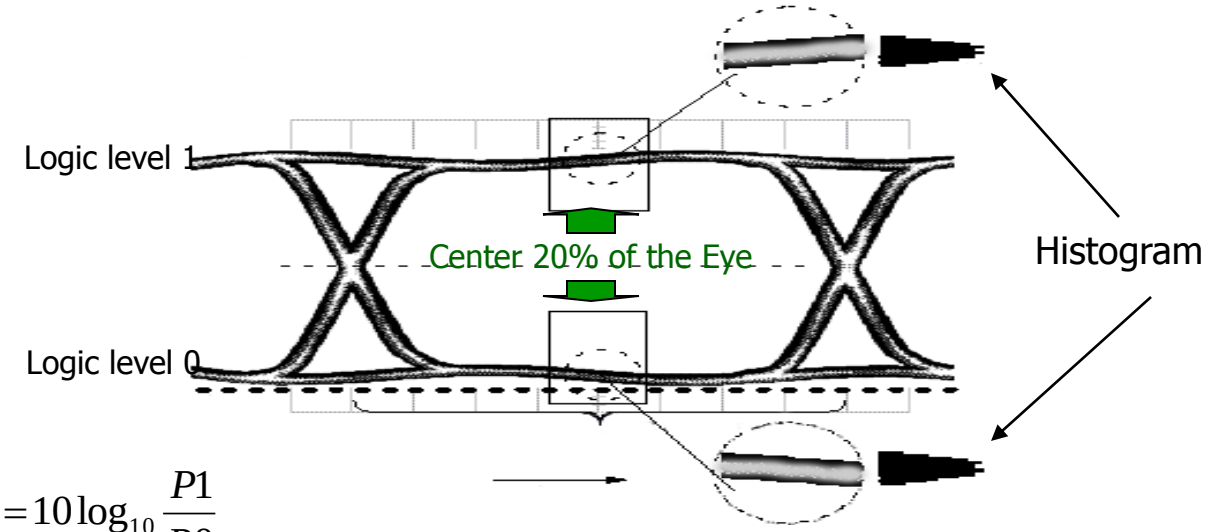


消光比测试-光接口测试的最大难点

- 工业标准对消光比的描述 (ER)
- 什么是消光比(ER)
- 消光比的重要性
- 影响消光比测试精度和可重复性的因素
- 泰克DSA8300 提高消光比测量的解决方案-“ER Calibrated”
- 标准消光比测量和经过 “ER Calibrated”消光比测量结果比较

消光比的定义

- ER（Extinction Ratio）为光模块发射逻辑“1”时的平均光功率和发送逻辑“0”时的平均光功率之比.
  - 在光眼图的中心的20%的位置测量直方图的平均值



$$ER = \frac{P1}{P0}, dB = 10\log_{10}\frac{P1}{P0}$$

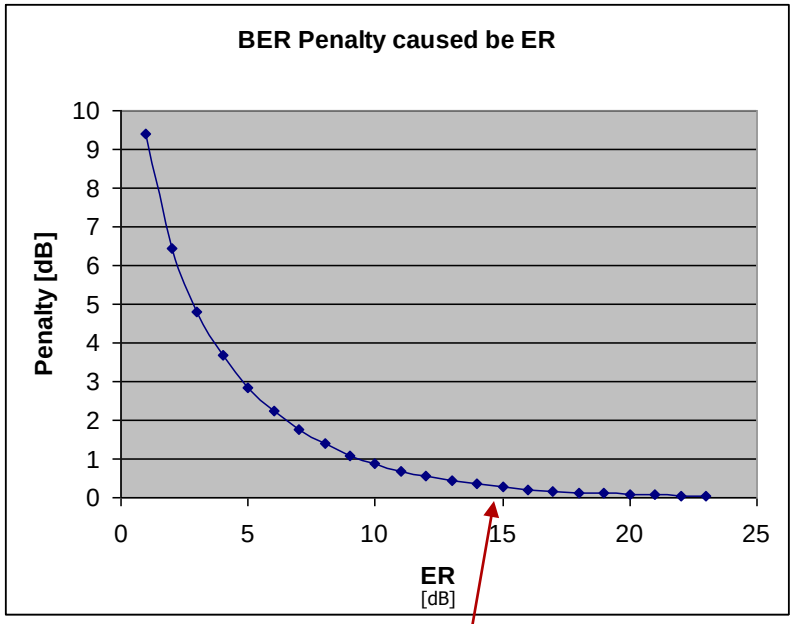
- ER 测量结果与逻辑“0”时电平和暗电平的相对值有很多影响（当激光器完全关闭不发光时）
  - 很小的0电平的变换/偏离都会明显的影响消光比的测试结果

为什么消光比测量结果非常重要?

- 标准规范中规定了消光比的性能指标以确保网络的互通性；所以对这一领域的各个提供商来说满足规范要求极为重要.
- 除满足规范要求外还有其他各原因也突显消光比测量的重要性:
  - 不同的元器件，模块和系统有不同的设计裕量
  - 良好的消光比性能可以改善误码率，是考量总体性能和质量的关键测量项目
  - 消光比测量值的波动直接影响产品的一次通过率，减小产出率和收益
  - 当验货检查结果和提供商不一致时使得工作复杂化

消光比应该在什么范围之内呢?

- ER 可以说明有多少光被浪费（相对暗电平的偏置的光功率没有承载任何信息）
- 在ER小于5dB后光功率损耗急剧加大，也就是说额外还需要光功率
- 如果ER大于15或是18，对此性能影响非常小



当ER > 15dB时对BER的改善非常小

➔ **That's why standards don't ask for 20 dB of ER**

➔ **And, that is why the precision of ER measurements is not critical beyond ER > 15 dB**

第一类误差来源：直流偏置校准(Dark Cal)

- 垂直偏置中的误差会导致相当大的 ER误差。
  - *适当的暗电平电平校准和进行补偿过的光模块测试激光眼图的结果为
    逻辑“1”电平 200uW
    逻辑“0”电平 7uW
    (ER = 28.6-to-1 or 14.56 dB).
  - *如果在相同的测试中包含+2uW 的偏置误差，那么
    逻辑“1”电平 202uW
    逻辑“0”电平; 9uW
    (ER = 22.4-to-1 or 13.51 dB).
    22%的线性变化，（或 -1.05 dB 差别）
- 光模块中的偏置随着温度而变化
  *(即使是很小的温度的改变，也需要运行暗电平校准或补偿。)

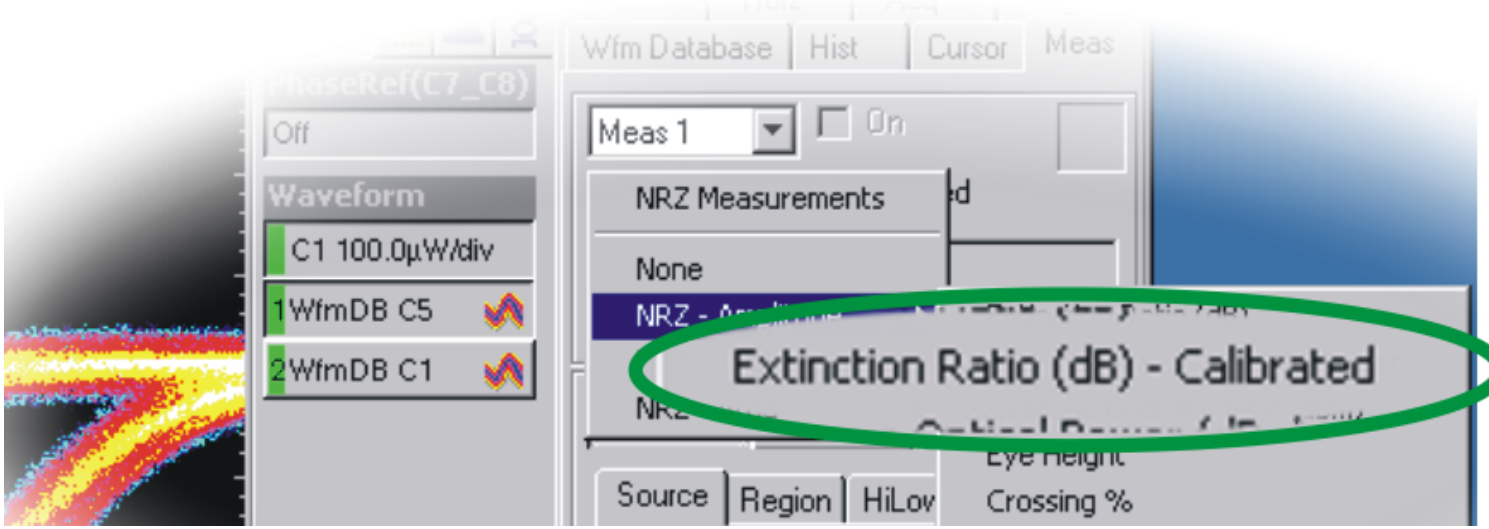
第二类误差来源-影响消光比测量精度的其他原因

- 4阶BT频响在不同频段存在的偏差
  - 中高频段范围
  - 低频失真 (near DC; finite settling time “dribble-up”)
- 群延迟
- 采样器的低频响应
- A/D的非线性失真
- 采样示波器模块结构影响：滤波器的射频开关引入损耗和失真，尤其在高频段

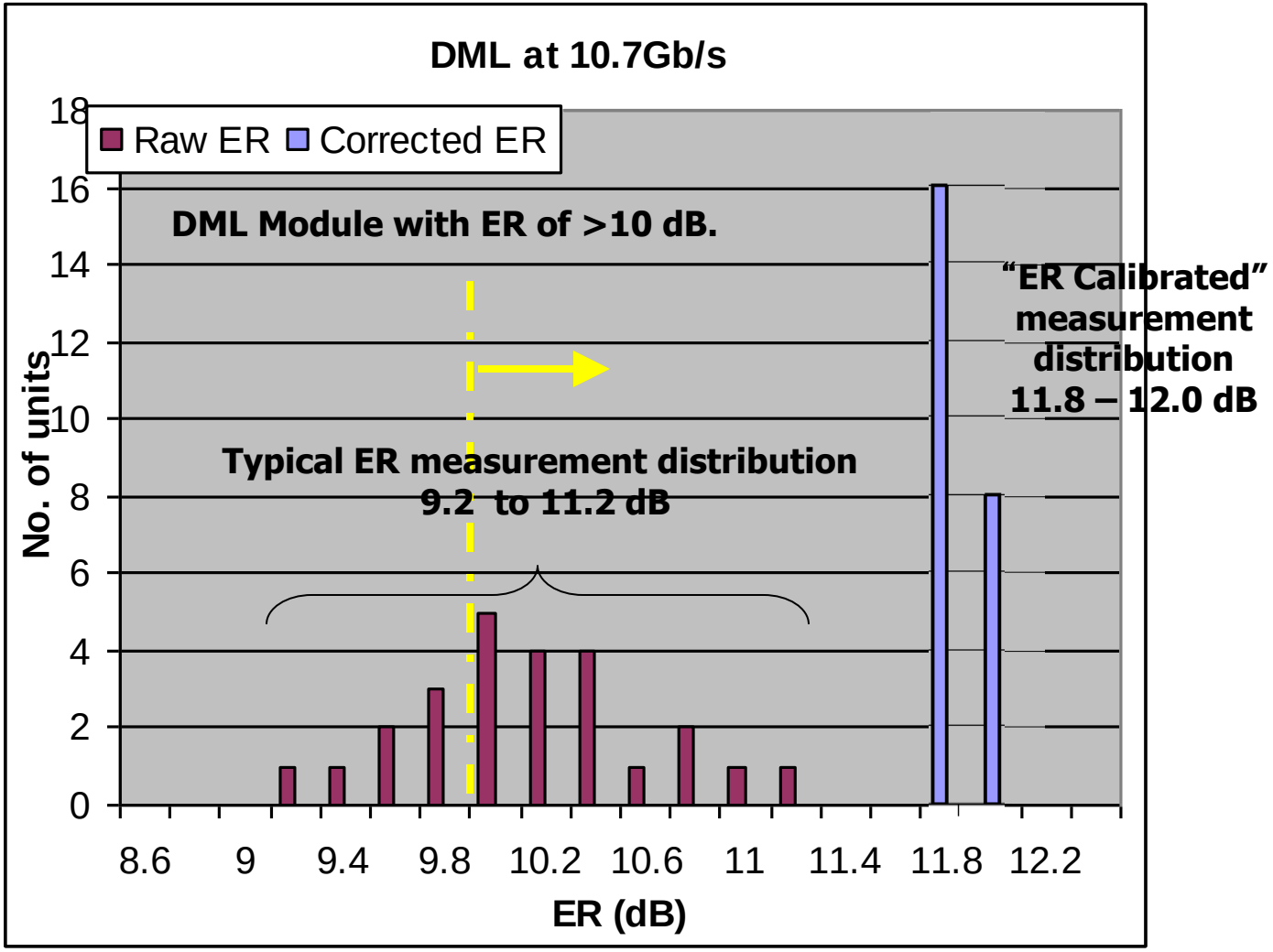
- 无法通过暗电平校准消除
- 这类误差影响一般都被忽略
- 在某些光采样示波器中没有直接或是间接的对这一指标进行说明
- DUT的一些特性有可能激化这类误差

泰克的解决方案：准确可重复的消光比测量

- 生成消除第二类误差来源的校准因子
- 通过专门的高精度消光比校准源提供校准
- 在工厂完成校准过程并将参数存于模块内
- 通过“ER Calibrated”测试项提供校准测试结果
  (同时保留旧的测试项目)
- 能同时提供绝对精度和可重复性测试指标



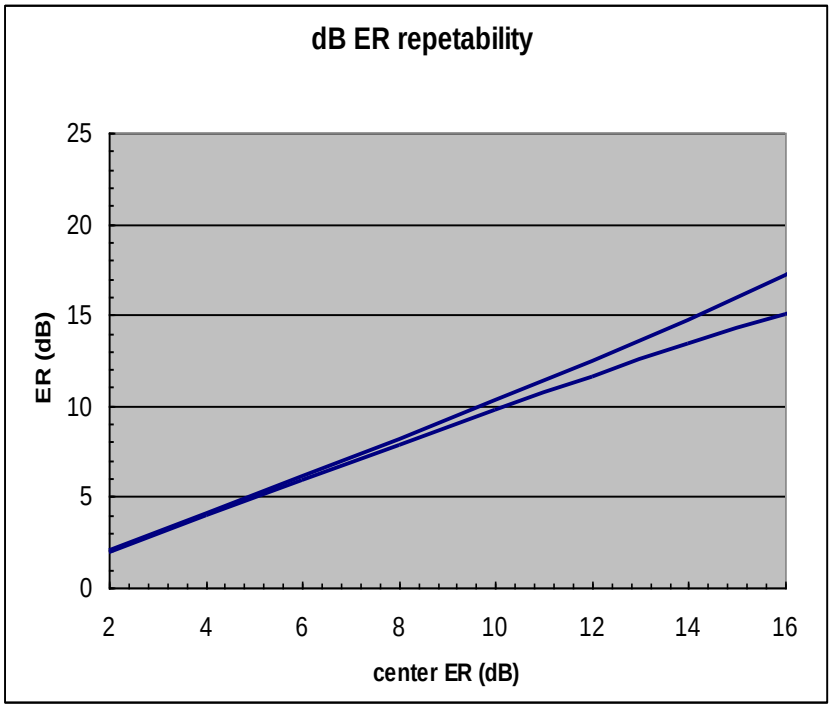
标准消光比和经过校准的消光比测量值分布比较-DML（直接调制激光器 ）



消光比校准后的规格－测试重复性

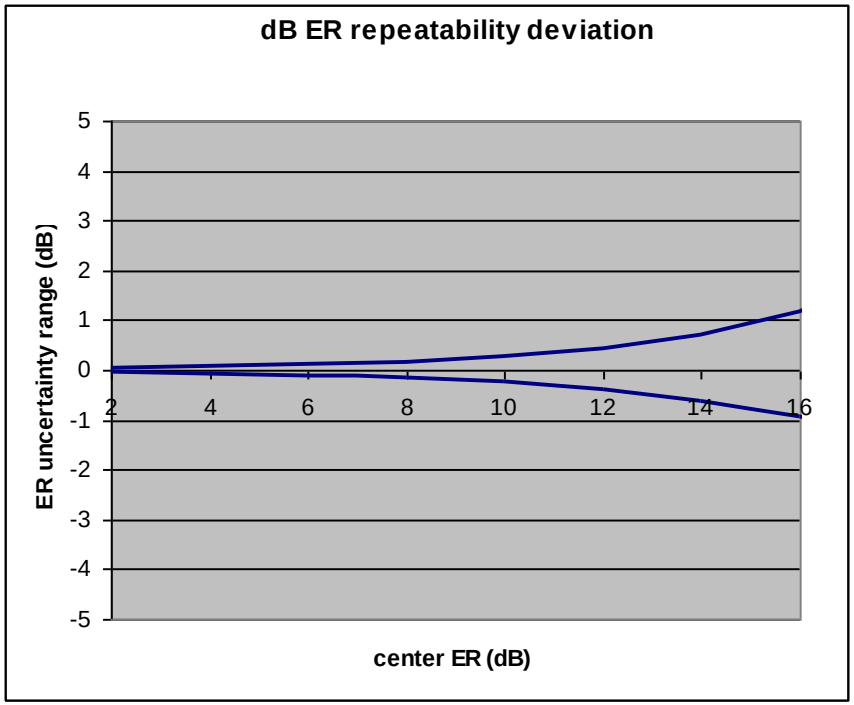
提供业内最优的消光比可重复性测试

经过ER Calibrated 典型的重复度可达: +/- 0.6 % (-0.25dB / +0.27dB at 10 dB)



重复测试值

理想值



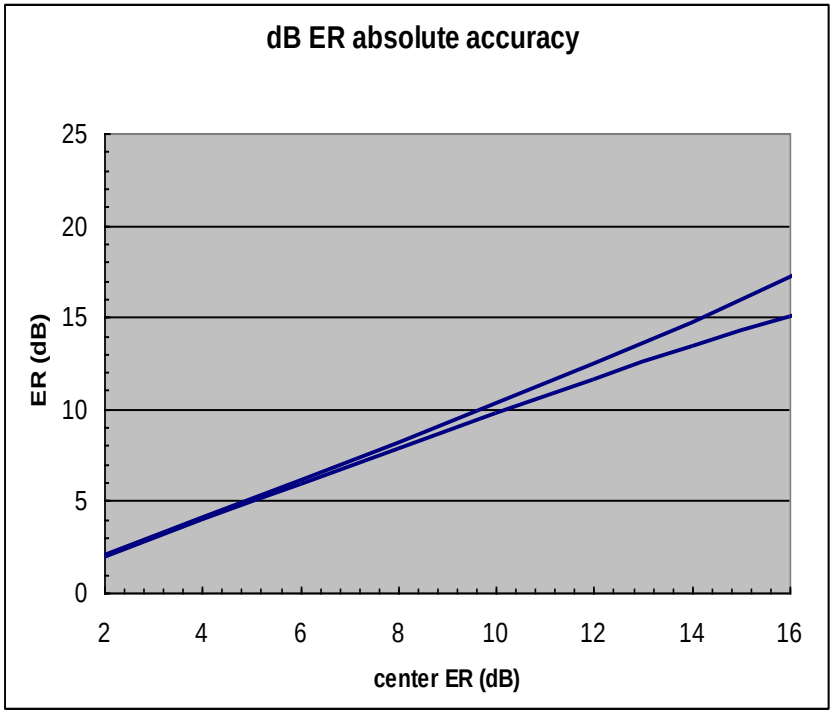
重复测试偏离度

理想值

消光比校准后的规格－测试精度

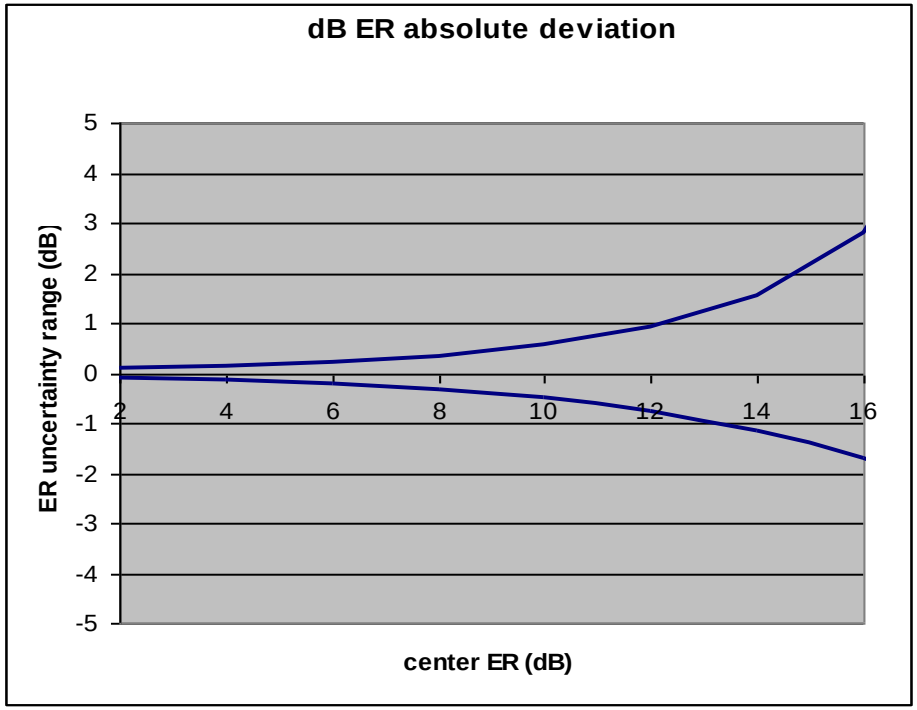
业内唯一可以提供高精度经过校准的消光比测试

经过ER Calibrated绝对精度可以达到: +/- 1.2 % (-0.49dB /+0. 56dB at 10 dB)



实际测试值

理想值



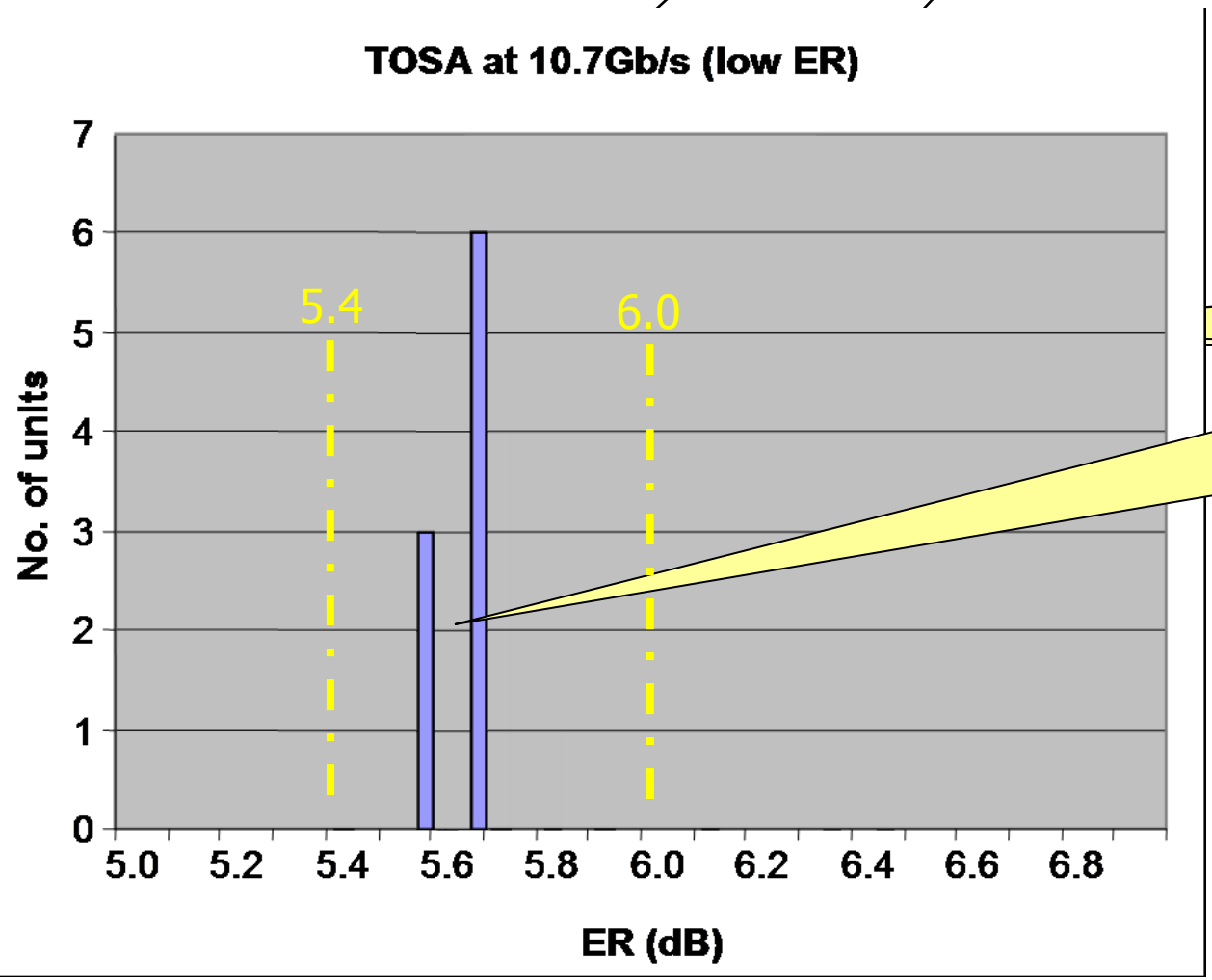
与理想值的偏离度

理想值

未较准消光比和经过校准的消光比测量值分布比较

You manufacture modules with ER >5.4 dB and <6dB.

低成本VCSEL
("垂直腔面发射激光器")
in a TOSA
("光发射次模块")



With the DSA8300 "**ER Calibrated**" everyone has this!

泰克的解决方案：准确可重复的消光比测量(免费标配功能)

- 去除影响消光比精度的第二类误差源，改进测试的可重复性和测试精度
- 通过专门的校准信号源和验证信号源保证校准结果

- 对于制造企业来说这意味着：

  更好的产出比，或更长的传输距离，或更多的裕量

- 对器件和模块以及模块使用者来说意味着

  质量和一致性验证更清晰

- 使用DSA8300的ER Calibrated增加你竞争力

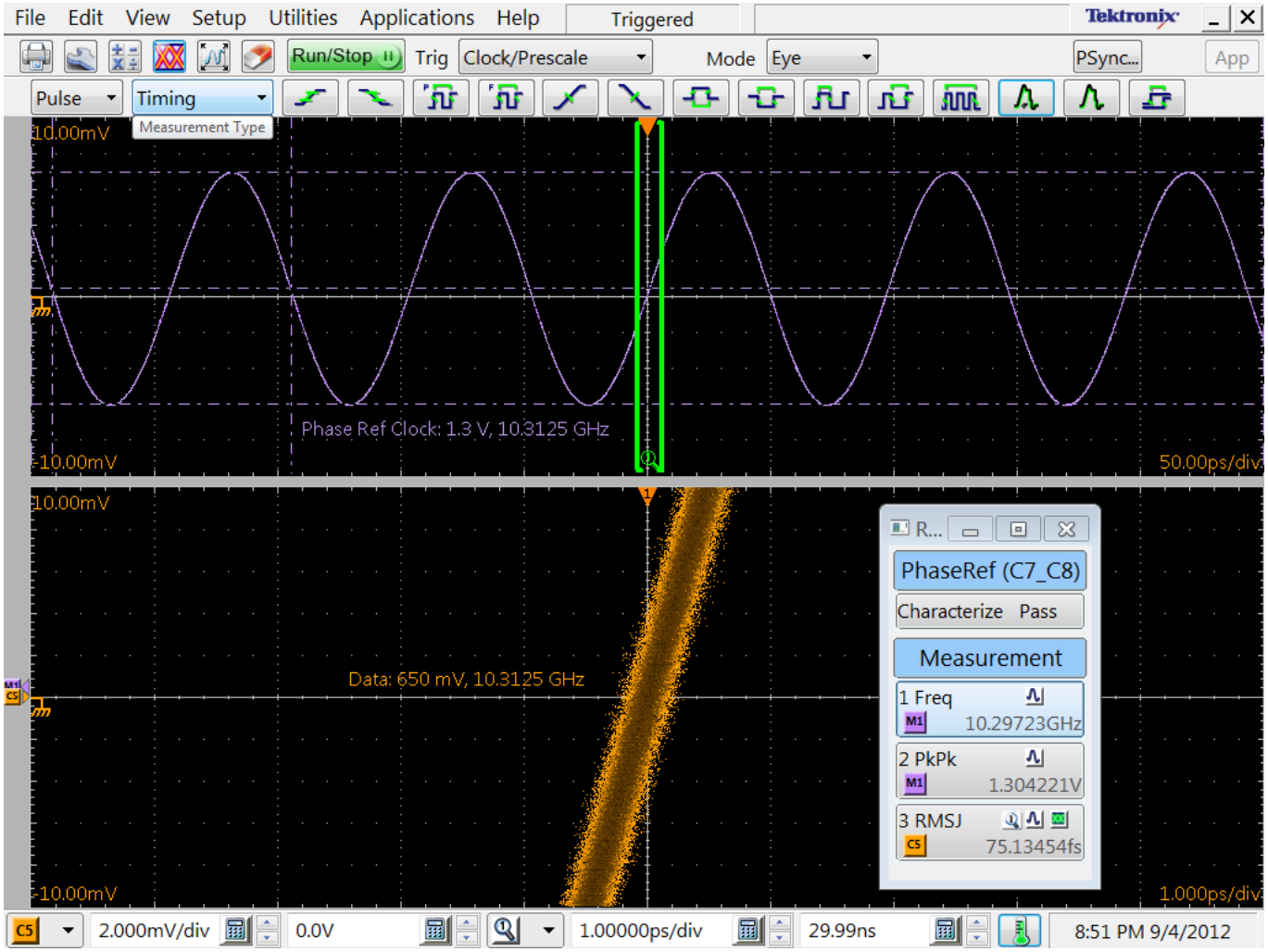
Measurement Challenges – Instrumentation Jitter

- Instrumentation jitter has two major components – random jitter and deterministic jitter.
  - Random jitter – when characterizing high performance devices, having the lowest possible instrumentation jitter is critical. Shown below is the amount of instrumentation jitter that would consume 5% of the user's jitter budget at the various standard data rates.

Standard	Bit Rate (Gb/s)	Unit Interval	Random Jitter (5% @BER=10^{-12})
16G Fibre Channel	14.025	71 psec	250 fsec
PCIe4.0	16.0	63 psec	225 fsec
100GBASE-R4	25.781	39 psec	140 fsec
SONET OTU-4 (CEI-28G-SR)	27.975	36 psec	129 fsec
40GBASE-FR	41.25	24 psec	86 fsec

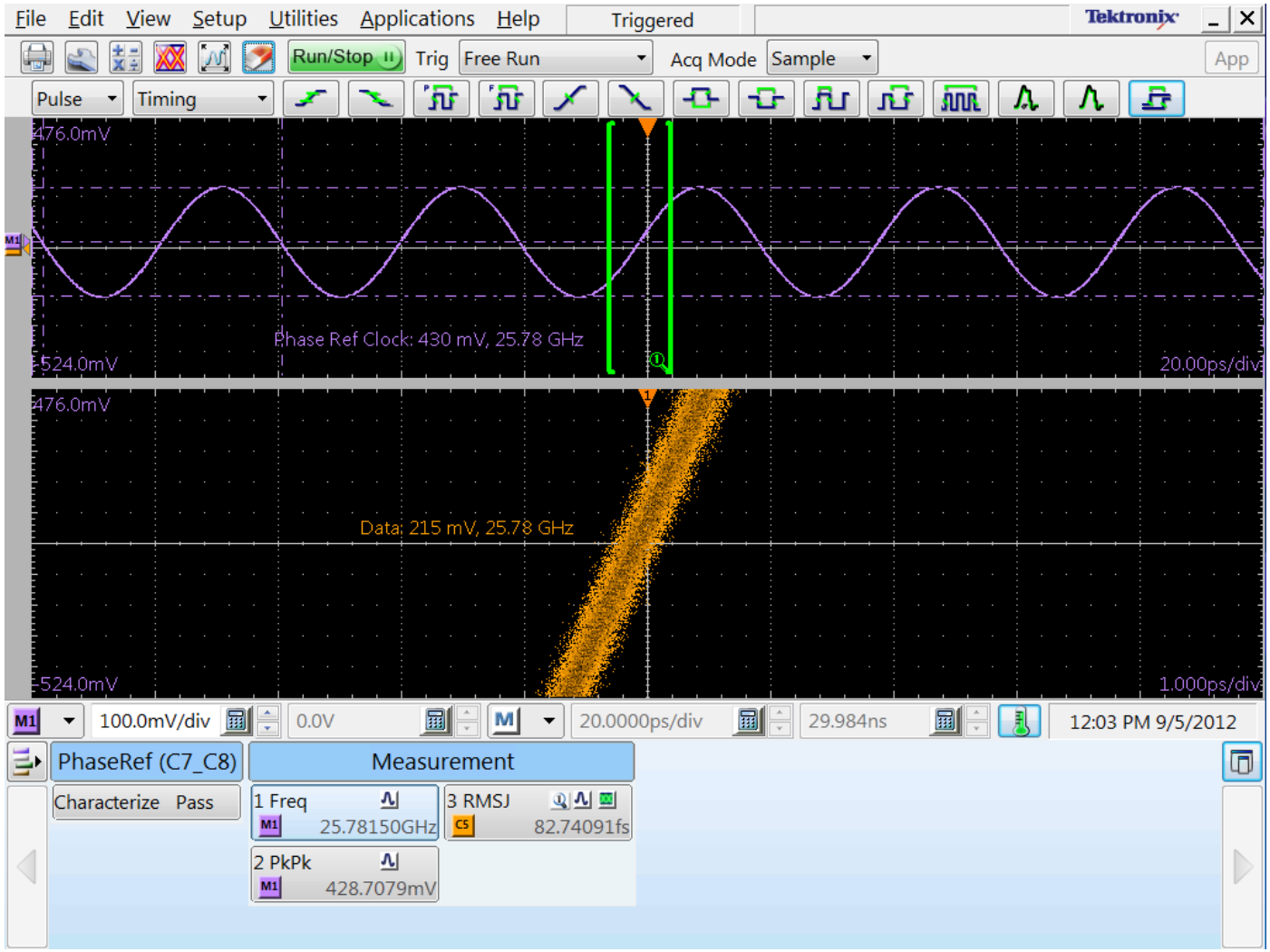
  - Deterministic Jitter – while there are many sources of deterministic jitter, a common source is data dependent jitter which is a strong function of the connection from the DUT to the instrumentation system. Minimizing this interconnect reduces the total instrumentation jitter.

Ultra low jitter floor – Clock signal acquired with 82A04B



- Phase Ref
  - 10.3125 GHz
    - 1.3 V
- Data Input:
  - 650 mV
- Jitter:
  - 75 fsec

Ultra low jitter floor – Clock signal acquired with 82A04B



- Phase Ref
  - 25.78 GHz
    - 430 mV
- Data Input:
  - 215 mV
- Jitter:
  - 83 fsec

DSA8300 Digital Serial Analyzer

DSA8300 Optical Module Portfolio

Multi-mode, Broad Wavelength (750 – 1650 nm) Modules	
80C07B	Supports rates to 2.7 Gb/s, high sensitivity, optional integrated clock recovery
80C08D New	Supports all of the 8/10 Gb/s applications, high sensitivity, optional integrated clock recovery, optional Integrated CR
80C12B	Supports rates from 155 Mb/s – 11.3 Gb/s, high sensitivity – data pick-off for external CRU e.g. CR125A
80C14	Supports rates from 8.5 Gb/s – 14.063 Gb/s, high sensitivity – data pick-off for external CRU e.g. CR175A

Single-mode, Long Wavelength (1100 – 1650nm) Modules	
80C11B New	Optical bandwidth to 30GHz, supports 10G bits up to14G+ standards, optional integrated CR
80C10C New	Optical bandwidth to 80GHz, supports all 40 and 100 Gb/s (4 x 25 Gb/s) standards, optional CR trigger pickoff for e.g. CR286A CRU, optional high sensitivity photo-receiver for use with external equipment (e.g. for optical BER testing with BERTScope)

Industry Leading, Versatility, Value, and Performance

NEW

- 80C10C
  - Up to 80 GHz Optical bandwidth
  - Industry's best noise performance @ 25G, 40G and beyond
  - Best signal fidelity, better mask margin and first pass yields
- **Versatility:** 80C10C, Option F1
  - The ONLY single module solution to 100GbE (4x25), OC768, G.709 FEC, OTU3, OTU4 (27.952 Gb/s), and 40GbE in a single module
- **Value:** 80C10C Focus Solutions:
  - Option F2 – 100GbE (4x25) ONLY compliance test solution
- **Performance:** 80C10C, Option F3
  - 40 GbE compliance test
  - 80 GHz Optical bandwidth, industry's leading
- Connectivity options for a complete calibrate system solution
  - **Option CRTP** – Clock Recovery Trigger Pickoff provides Data and Data_ outputs for connectivity to CRU and / or BERTScope (high optical amplitude required for BERTScope)

NEW

  - **Option HSPR** – High-Sensitivity Photo Receiver provides independent optical input and electrical outputs that can be used with CRU and / or BERTScope or other equipment

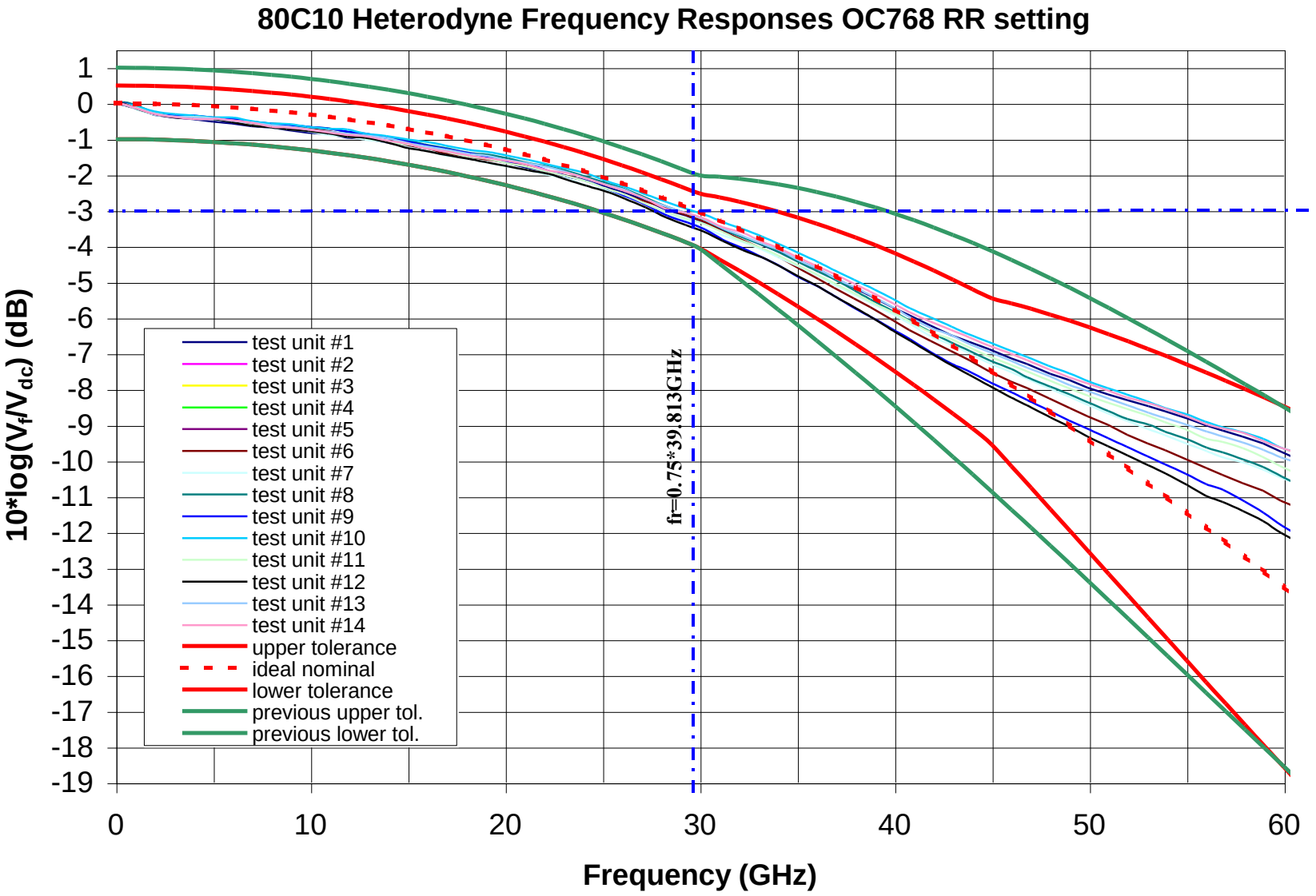
80C10C, Option F1, F2, and F3 Configurations
Next Generation Of Optical Test

Optical Bandwidth / Integrated ORR	Versatility Tektronix 80C10B Opt. F1[1]	Value Tektronix 80C10B Opt. F2[1]	Performance Tektronix 80C10C Opt. F3[1]
- Max. bandwidth	70 GHz	55 GHz	80 GHz
- Selectable bandwidths		-	65 & 30 GHz
40Gbs G.709 FEC Telecomm - 43.02 GHz & 44.5 GHz	✓	-	✓
40GbE Datacom - 41.25 GHz	✓	-	✓
OC768 40 GHz Telecom - 39.8 GHz	✓	-	✓
100GbE-4X FEC Datacom - 27.7 GHz	✓	✓	-
100GbE-4X Datacom - 25.8 GHz	✓	✓	-
Clock Recovery Trigger Pickoff, Option CRTP[2]	Available	Available	Available
High-Sensitivity Photo Receiver, Option HSPR[2]	Available	Available	Available

[1] Customer must select one from Options F1, F2, or F3

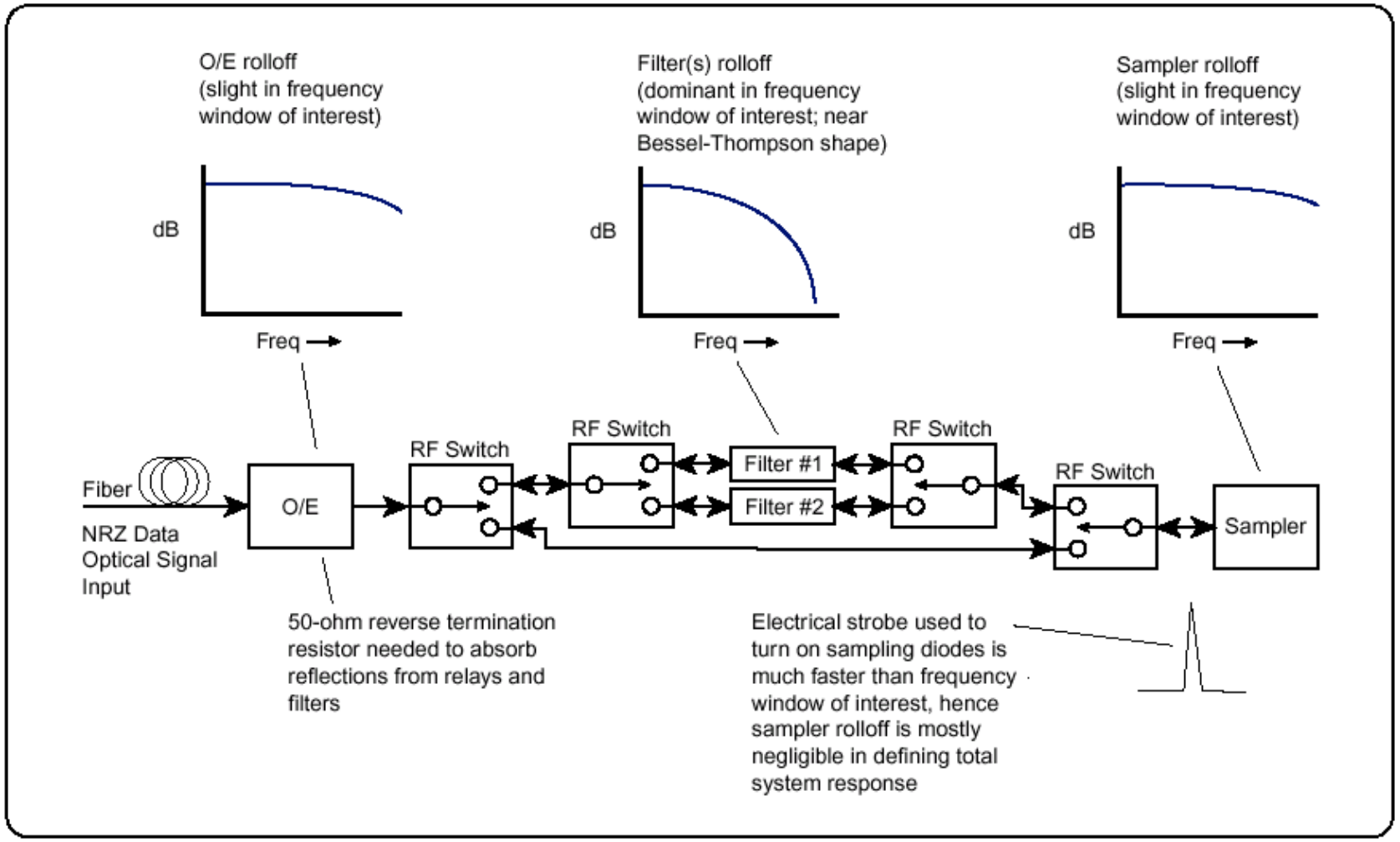
[2] Option CRTP and HSPR are mutually exclusive…both cannot be ordered in the same 80C10C module.

Reference Receiver Repeatability – 39.8Gbps



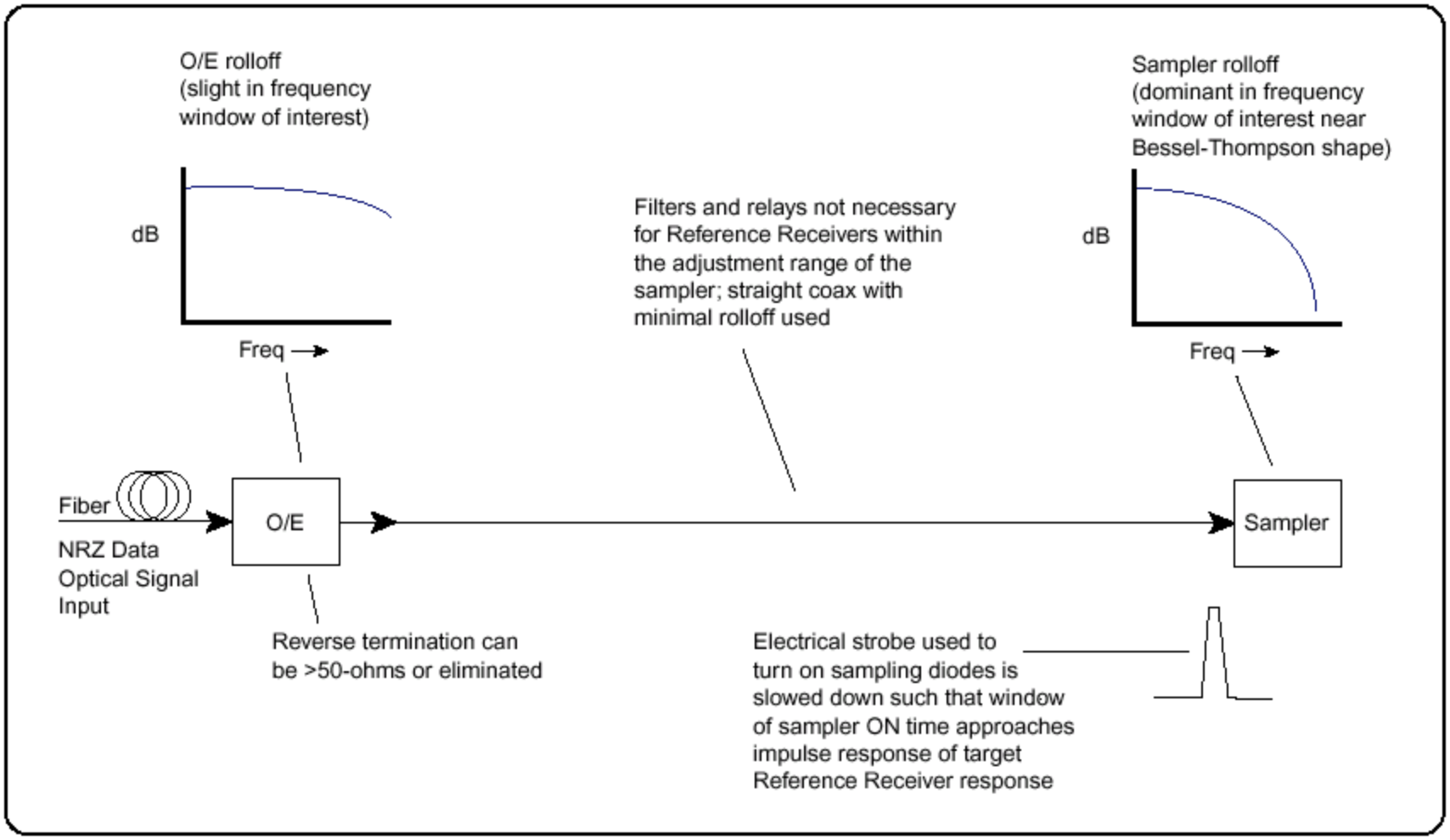
Superior 40 Gbps Reference Receiver Performance

Traditional ITU Filtering Methodology



Superior 40 Gbps Reference Receiver Performance

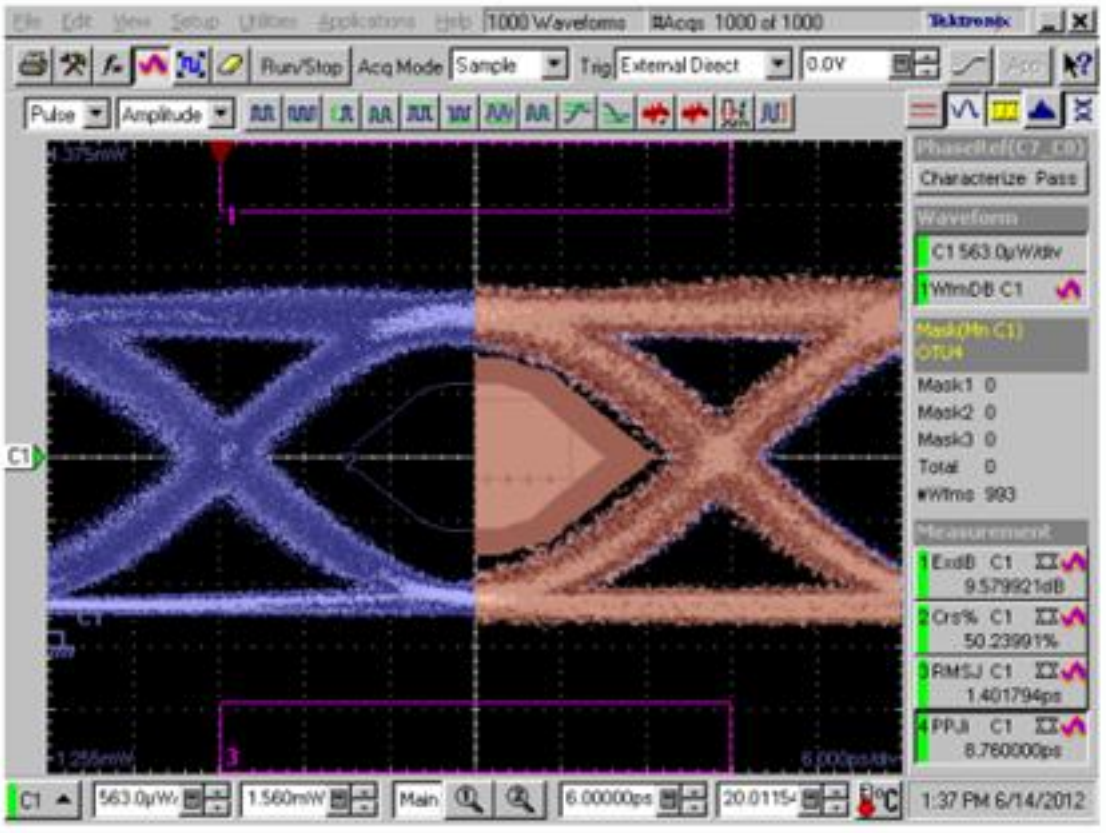
Tektronix Proprietary Filterless Design



New 80C10C Optical Module
Unmatched Sensitivity for 100G (4 x 25G) Applications

OTU4 transceiver: 3.5 dBm, 1310nm, 27.95 Gb/s, 9µm SMF

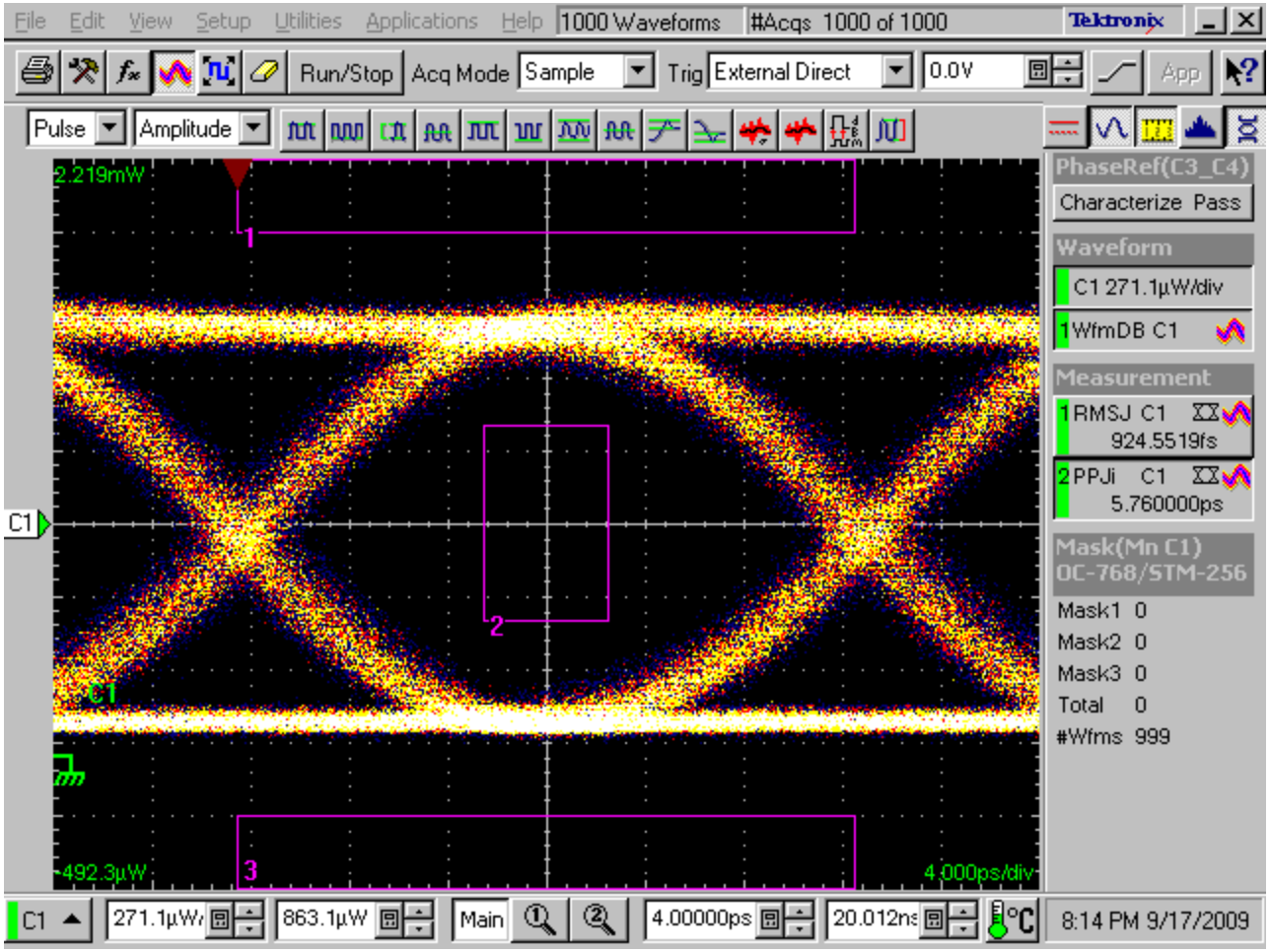
New Tektronix 80C10C



Alternative Solution

Tektronix

40Gb/s NRZ Eye Diagram(testing at customer side)



80C14 Optical Module
16GFC Single/Multi-mode Solution

80C14 Optical Module

Performance Specifications	
Single and multi-mode	9, 50, 62.5μm core
Supported wavelengths	700 - 1650 nm
Maximum Optical Bandwidth	14 GHz
Optical Reference Receivers	All 10 Gb/s standards + 8 and 16 GFC
Sensitivity	-12 dBm at 850nm (-15 dBm at 1310 nm)
Buffered electrical data pick-off to support external clock recovery instrument	Recommended Tektronix CR175A or CR286A

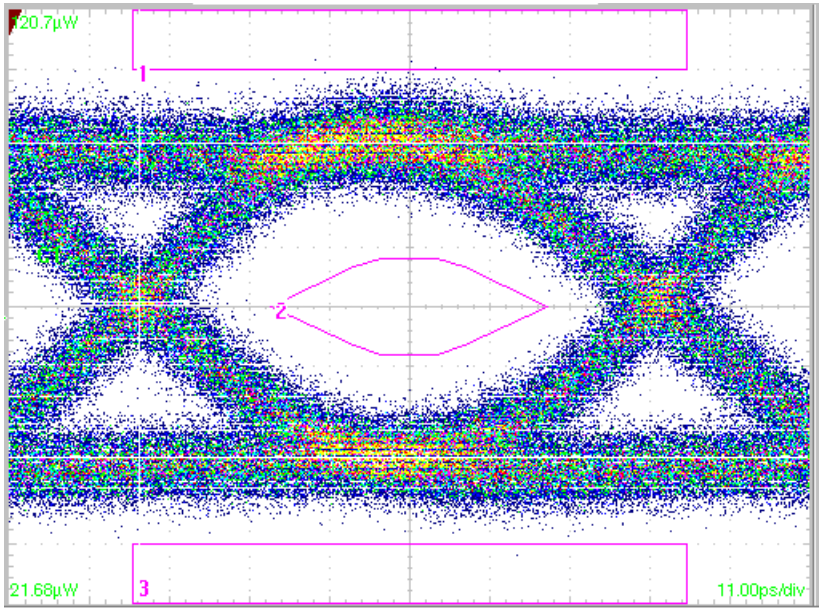
Standards Supported

Standard	Data Rate
8 GFC (old)	8.500 Gb/s
OC192/STM64	9.953 Gb/s
10GBase-W	9.953 Gb/s
10GBase-R	10.31 Gb/s
40GBase-LR4	9.953 Gb/s
10G EPON	9.953 Gb/s
100GBase-SR10	10.31 Gb/s
10GFC	10.51 Gb/s
G.975 FEC	10.66 Gb/s
G.709 FEC	10.71 Gb/s
10GBE FEC	11.10 Gb/s
10 GFC FEC	11.317Gb/s
12.5 Gb/s FEC	12.50 Gb/s
16 GFC	14.025 Gb/s
Infiniband FDR	14.063 Gb/s

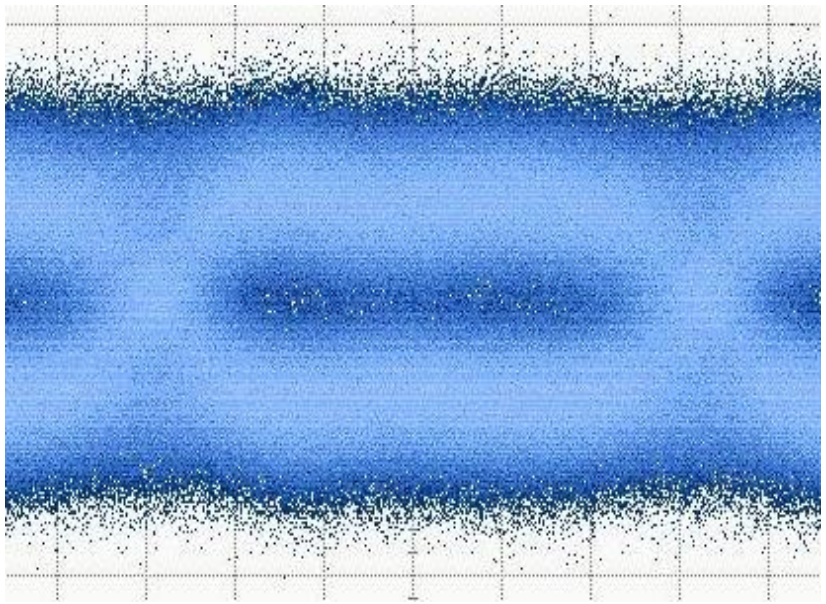
New 80CXX Optical Module
Unmatched Sensitivity for 16G FibreChannel

16GFC SW transceiver: -11dBm, 850nm,14.025Gb/s, 50um MMF

New Tektronix 80C14



Alternative Solution

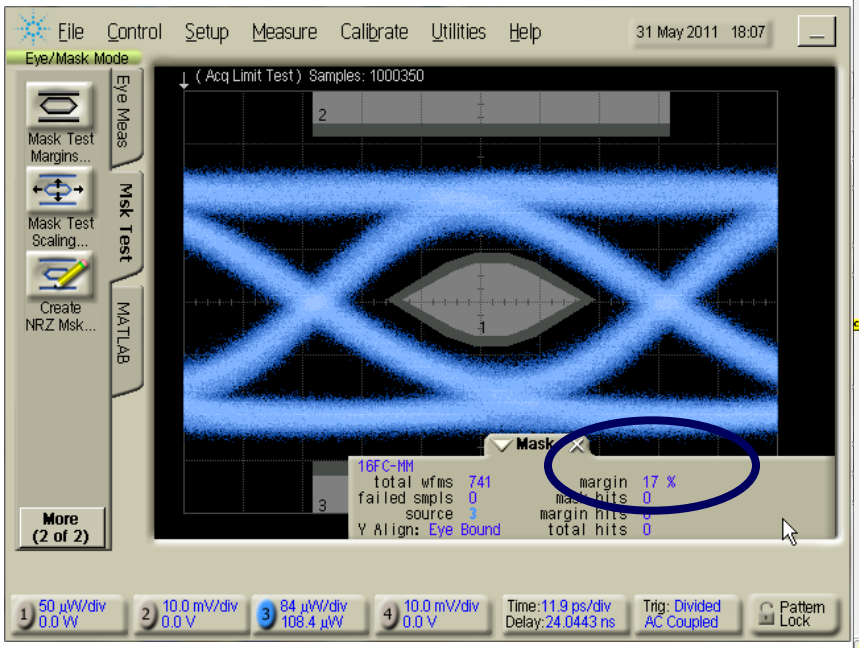


Tektronix

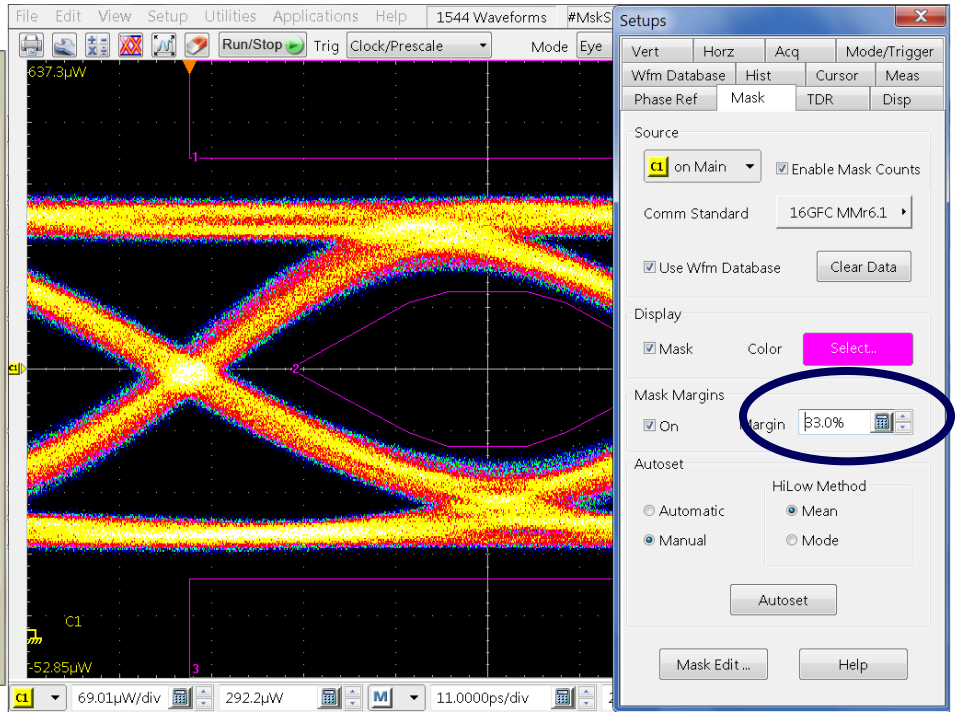
Mask Test Results – 80C14 Has More Mask Margin

- Tektronix mask has better margin: 33% vs. 17%

The power level is above the minimum allowed by the 16GFC standard. A significantly higher power level would lead to a decrease in mask margin difference.



86105D

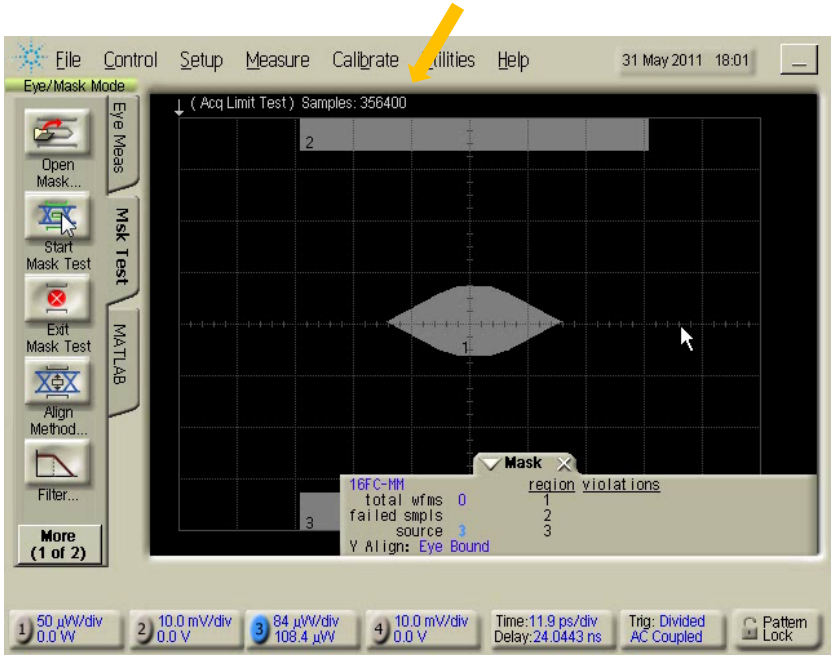


Tek 80C14

Mask test

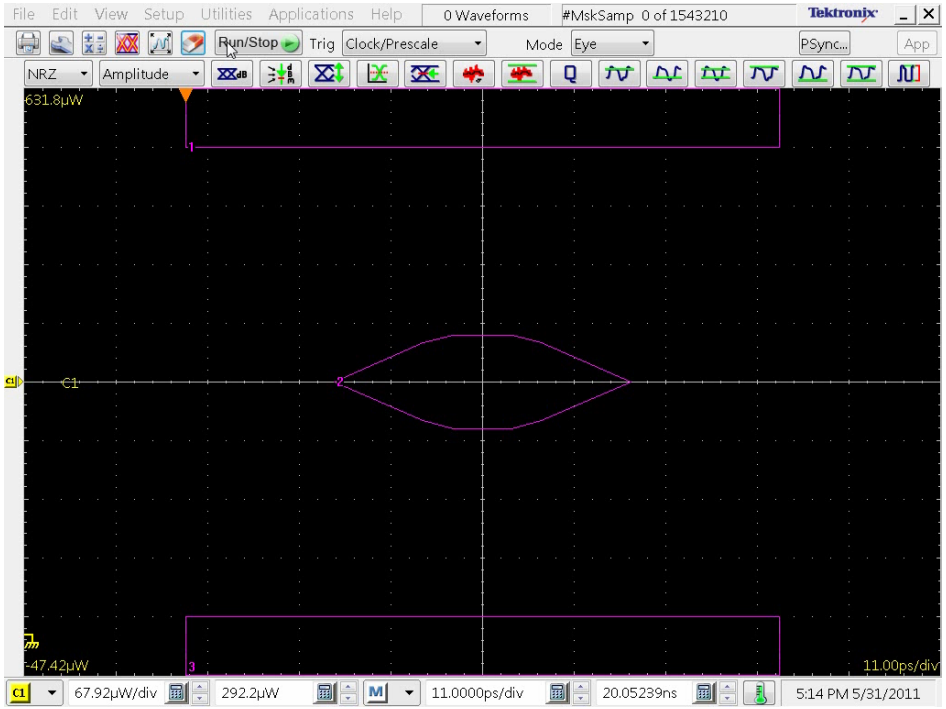
- Speed was measured w/o the “Remote Desktop” resp. “VNC”;
  what is shown in the video on the left is 1 to 2 s slower than measured value (shown on the caption) due to VNC, presumably this problem is due to old CPU and new product would not exhibit this slow-down. The video on the right doesn’t exhibit noticeable slow-down.
- Tek oscilloscope: the Samples counted are really the whole screen; to achieve true 1MS in the mask area the acquisition was set to an increased value of 1.54 MS

Done: 1MSamples in 32 s



DCAj

Done: 1MSsamples in 11.7 s



Tek DSA8300

80C12B Optical Module
Tributary and 10G Rate, Single/Multi-mode Solution

- 80C12B
  - Performance Specifications
    - Single and multi-mode (9, 50, 62.5µm core)
    - Supported wavelengths (700 – 1650 nm)
    - Maximum optical bandwidth – 12 GHz
    - Optical Reference Receivers – All 125 Mb/s through 11.3 Gb/s standards
    - Buffered electrical data pick-off to support external clock recovery
      - » Recommended clock recovery, Tektronix CR175A or CR125A
  - 80C12B Module with available ER-Calibrated for accurate repeatable ER measurements
    - Accuracy: ±1.2% (–0.76 dB /+0.92 dB at 12dB)
    - Repeatability: ±0.6% (–0.39 dB / +0.42 dB at 12 dB)

Three configuration strategies available:

1. Any 4 Trib. rate filters, options F0 through F12
2. All 10 G rates only (8.5 Gb/s to 11.3 Gb/s filters only), Opt. 10G only
3. Select any 3 Trib rate filters, plus 10GP (10G rates)

Filter Opt.	Rate(s) Supported
F0	Unfiltered 12 GHz bandwidth and 8.500 ORR filter
F1	155.52 Mb/s Optical Reference Receiver (ORR) Filter
F2	622 Mb/s ORR Filter
F3	1.0625 Gb/s ORR Filter
F4	1.250 Gb/s ORR Filter
F5	2.125 Gb/s ORR Filter
F6	2.488, 2.500 Gb/s ORR Filter
F7	2.666 Gb/s ORR Filter
F8	3.125, 3.188 Gb/s ORR Filters
F9	4.250 Gb/s ORR Filter
F10	5.000 Gb/s ORR Filter
F11	6.144 Gb/s ORR Filter
F12	7.373 Gb/s ORR Filter
10G	8.500, 9.95, 10.31, 10.51, 10.66, 10.71, 11.1, 11.3 Gb/s ORR Filters plus Unfiltered full bandwidth path (typically 12 GHz)
10GP	8.500, 9.95, 10.31, 10.51, 10.66, 10.71, 11.1, 11.3 Gb/s ORR Filters plus Unfiltered full bandwidth path (typically 12 GHz) – specify 3 additional filter options (F1-F12) to be included.

Tektronix

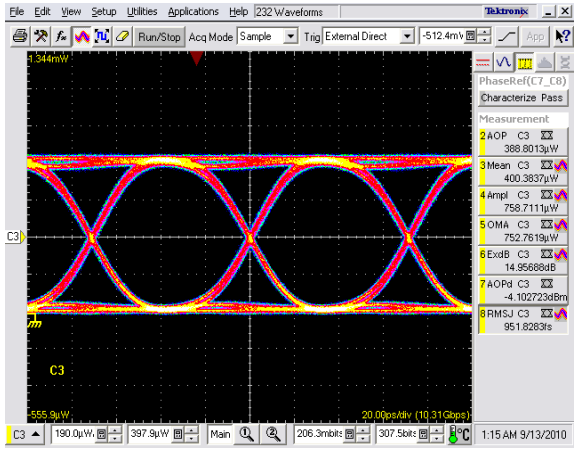
10GbE to100GbE Optical Compliance Testing
DSA8300 ALL-IN-ONE Solution

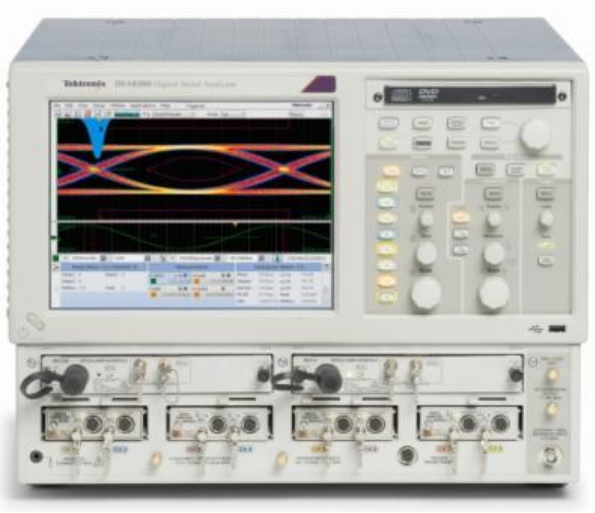
Tektronix DSA8300 All-In-One System

+ 80C12B Optical Module (155 Mb/s to 11.3 Gb/s)
+ 80C10C-F1 Optical Module (25.7 Gb/s to 44.5 Gb/s)

The Only ALL-IN-ONE Solution with:

- All major ORRs from 155 Mb/s thru 44.5Gb/s
  - Highest repeatability & best sensitivity
    - SMF and MMF support to 12G
  - Up to 3x throughput over alternative
    - 425 fs $_{RMS}$ native jitter
  - 100 fs $_{RMS}$ jitter when equipped with 82A04B
- Tektronix CR to 28.6 Gb/s, third party to 44.5 Gb/s
  - Integrated clock recovery trigger pickoff
- Calibrated Extinction-Ratio (ER) Measurements[1]





DSA8300 Digital Serial Analyzer
TDR and Electrical Module Portfolio

- TDR / Electrical Modules

Electrical TDR Modules	Channels	Vertical Resolution	Bandwidth	TDR System Incident Rise Time (10%-90%)	TDR System Reflected Rise Time (10%-90%)
80E04	2	16 bits	20 GHz	23 ps	28 ps
80E08	2	16 bits	30 GHz	18 ps	20 ps
80E10	2	16 bits	50 GHz	12 ps	15 ps

- Electrical Module

Electrical Modules	Channels	Vertical Resolution	Bandwidth	Risetime (10%-90%)	Monolithic or Remote
80E01	1	16 bits	50 GHz	7 ps	Monolithic
80E03	2	16 bits	20 GHz	17.5 ps	Monolithic
80E06	1	16 bits	70+ GHz	5 ps	Monolithic
80E07	2	16 bits	30 GHz	11.7 ps	Remote (2 meter)
80E09	2	16 bits	60 GHz	5.8 ps	Remote (2 meter)

BERT Portfolio Lineup

BERTScope (BSA)
- Main product
- BERT & Scope
- Serial & Communications

Clock Recovery (CR)
- Used with BERTs & Scopes
- Jitter measurement

Pre-Emphasis (DPP)
- Add-on to BERTScope Generator to model Standards specific signal pre-emphasis requirements.

BitAlyzer
- Basic BERT & Scope

New Product Launch

- ☐ 28.6G
- ☑ 26G
- ☑ 17.5G
- ☑ 12.5G
- ☑ 8.5G

- ☑ 28.6G
- ☑ 17.5G
- ☑ 12.5G

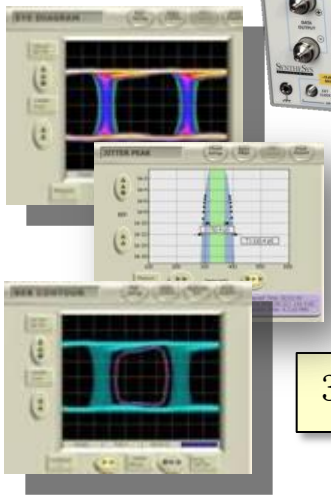
- ☑ 12.5G

- ☑ 1.5G/1.6G

What is a BERTScope?

A Combination BERT and Scope for Computer Bus and Communications Serial Data Applications

1 Pattern Generator (with optional Stress) sends bits, e.g. a PRBS pattern

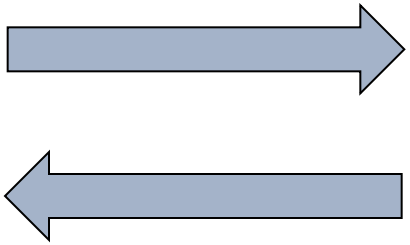


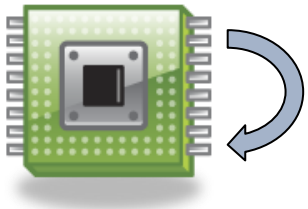
3 BER measurements also used for scope-like analysis

A Typical Receiver Test Setup

From Stressed Pattern Generator

loopback



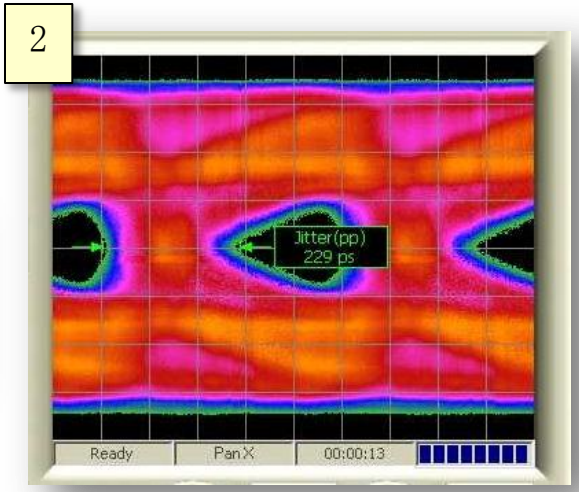


To Error Detector

Device Under Test (DUT)

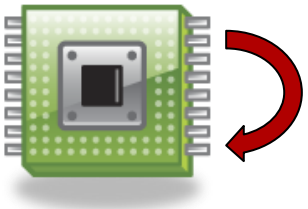
2 Bits come back from DUT to Error Detector and compared to expected pattern for Bit Error Ratio (BER) measurement.

Start Testing Quickly



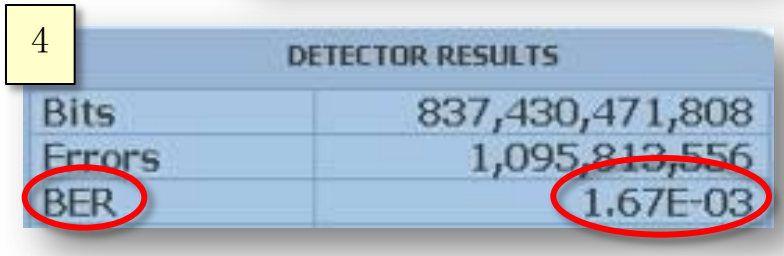
From Stressed Pattern Generator

3 *loopback*



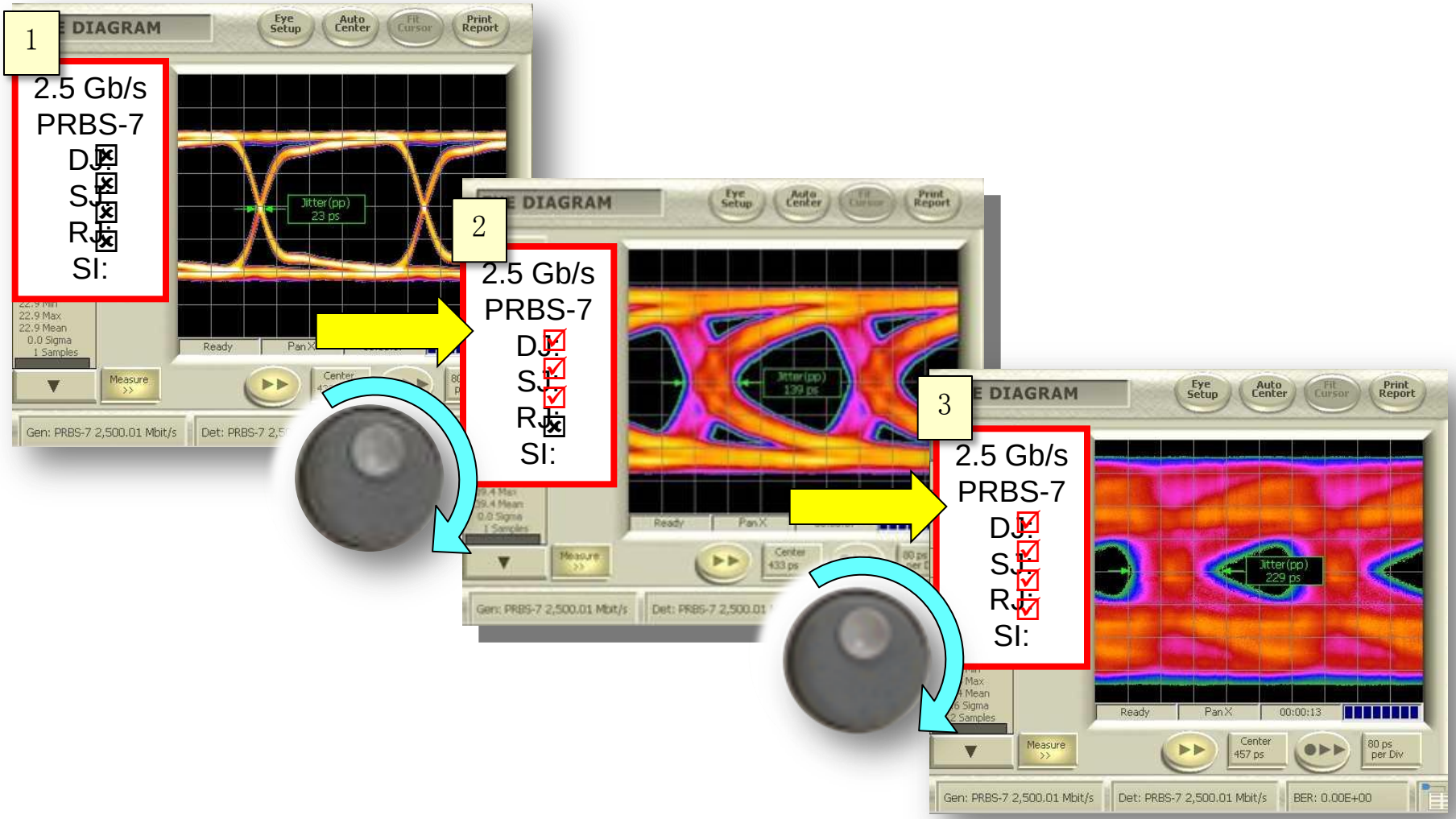
To Error Detector

Device Under Test (DUT)



1. Recall stressed eye configuration
2. Apply stressed eye signal to DUT's receiver
3. DUT loops received bits back to BERTScope Error Detector
4. BERTScope counts any errors

Dynamically change Data Rate, Stress, Pattern



New Product Description

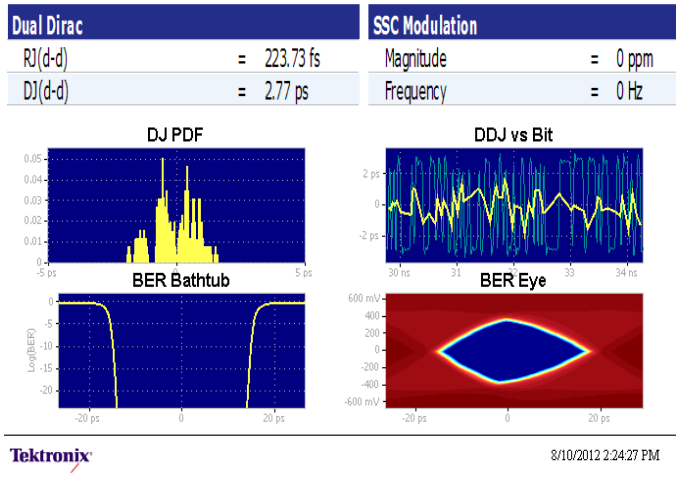
- BERTScope BSA286C
  - BSA286C - High performance BERTScope, offers unique performance and jitter specifications required by the emerging and diverse high speed (100Gbps) COMMS market.
  - Key features:
    - 1-28.6Gbps spec'd performance, with non-calibrated performance to 29G.
    - Sub 300fSec Rj Tx noise floor, essential and a unique differentiator for the performance COMMS market. This puts the BSA into one of the lowest jitter BERT's in the market.
    - New MFG Calibration process to guarantee low jitter PG properties and better unit to unit consistency.
    - The only system on the market with continuous (no hole) coverage from 1Gbps to 29.0Gbps.
    - Unmatched versatility and ease of use.
    - Optional full rate error detection (28GED) without the use of external de-mux systems.
    - Support for 32G Fibre Channel, 802.3ba (100GE) and ITU-709 standards

- Tektronix is now offering a new category of low intrinsic jitter capabilities and versatile debug and measurement capabilities

Electrical Signal Properties at 28G

Data Source: CH1	Data Rate: 28 Gbps	Filter: False
SSC: Off	Pattern: 127 bits	Channel: False
Phase Reference: 7 GHz	Sample Count: 52.70 k	Equalizer: None

Jitter (Decision Threshold: -7.73 mV)			**Noise** (Sampling Phase: 0 UI)		
Random Jitter			**Random Noise**		
RJ (RMS)	=	199.01 fs	RN (RMS)	=	4.98 mV
RJ(h) (RMS)	=	160.06 fs	RN(v) (RMS)	=	4.98 mV
RJ(v) (RMS)	=	118.26 fs	RN(h) (RMS)	=	108.30 uV
Deterministic Jitter			**Deterministic Noise**		
DJ	=	3.59 ps	DN	=	161.33 mV
DDJ	=	3.17 ps	DDN	=	155.62 mV
DCD	=	198.77 fs	DDN(level 1)	=	144.05 mV
DDPWS	=	1.13 ps	DDN(level 0)	=	171.04 mV
PJ	=	144.94 fs	PN	=	4.53 mV
PJ(h)	=	97.27 fs	PN(v)	=	4.53 mV
PJ(v)	=	107.46 fs	PN(h)	=	65.82 uV
Total Jitter @ BER			**Total Noise @ BER**		
TJ (1E-12)	=	5.92 ps	TN (1E-12)	=	220.38 mV
Eye Opening (1E-12)	=	29.79 ps	Eye Opening (1E-12)	=	684.89 mV
			Eye Amplitude	=	905.27 mV



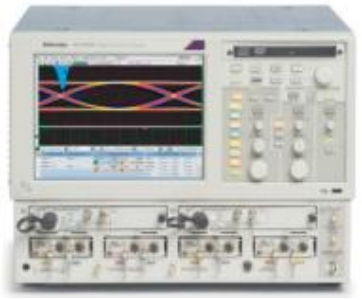
10GBASE-CR4 and 10GBASE-CR10 Interference Tolerance Parameters

Parameter	Test 1 values	Units
Target BER	10^{-12}	
Maximum fitted insertion loss coefficients	$a_1 = 2.15$ $a_2 = 0.78$ $a_4 = 0.03$	dB/√GHz dB/GHz dB/GHz^2
Applied SJ[a] (min peak-to-peak)	0.115	UI
Applied RJ[b] (min peak-to-peak)	0.13	UI
Applied DCD (min peak-to-peak)	0.035	UI
Calibrated far-end crosstalk (min RMS) Calibrated ICN (min, RMS) – σ_{nx}	6.3 3.7	mV mV

10/100G TX/RX optical testing Solutions

Tektronix has answers for 100G

- DSA8300 Sampling Oscilloscope
  - >80GHz Bandwidth
  - <100 fsec jitter noise
  - Pass/Fail at high throughput
  - BUJ-Based Jitter Analysis



- BSA286C Bit Error Rate Tester
  - 28.6 Gb/sec Data Rate
  - Low intrinsic jitter
  - Stressed, calibrated PRBS31 patterns
  - Error location & Jitter Analysis

- OM4000 Coherent Lightwave Analyzer
  - DP-QPSK Analysis
  - Constellation Mapping to BER
  - Works with RT or ET Scopes